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Journal

—OF THE—

American Ceramic Society

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries

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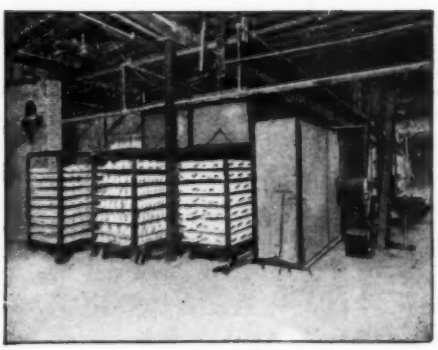

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Editor: E. W. WASHBURN; **Associate Editors:** L. E. BARRINGER, A. V. BLEININGER, R. L. CLARE, E. P. POSTE, H. RIES, F. H. RHEAD, R. B. SOSMAN, R. T. STULL, E. W. TILLOTSON

Vol. 4 **October, 1921** **No. 10**

EDITORIAL

THE TRIBUTE TO PROFESSOR ORTON

It is fitting that in the pages of the Society's JOURNAL there be made a permanent record of the work of the resolution committee in transmitting to Professor Orton the resolution of appreciation adopted by the Society at the Columbus meeting. The resolution itself was appropriately engrossed by Ralph Fletcher Seymour and was transmitted to Professor Orton by W. P. Gates, chairman of the committee. The text of the resolution, together with Chairman Gates' letter of transmittal and Professor Orton's acknowledgment are given in full below:

Chairman Gates' Letter of Transmittal

MY DEAR ORTON:

At last I have gotten the resolution engrossed and signed and it is now going into the frame and then to you. Really it was a hard resolution to write and I felt my inefficiency. Words can not express the esteem in which the Society holds you or their appreciation of the work you have done. Had you not entered into the field and shown your untiring energy as you did, the present condition of the clay working interests would have been far different than it is. When the history comes to be written

your part will be appreciated. Generally, the appreciation only comes when the man is dead but I am very glad that in your case there is wide appreciation now and there will be more and more as time goes on. As one who should do much and has done but little, I greet you as a master at accomplishment. Please remember, when you see the resolution, that it is but a weak expression of the esteem and love the whole Society has for you. Very honestly and sincerely— W. D. GATES, *Chairman*

The Resolution

WHEREAS, the American Ceramic Society, in Convention assembled at Columbus, Ohio, naturally recall memories of the first meeting held in the same place twenty-two years ago, and—

WHEREAS, it is remembered that the inception of this Society was from the mind of and directly due to the untiring effort and the winning personality of Edward Orton, Jr., who then gathered in the men to form it, and—

WHEREAS, for twenty years thereafter, and until his country demanded his services, Professor Orton worked untiringly and unselfishly, giving freely of his knowledge, his energy and his marvellous personality, to the growth and upbuilding of this Sosiety, and—

WHEREAS, the present condition of the Society is directly traceable to his generous and continued effort:

Now therefore, be it resolved that the heartfelt thanks of the Society be tendered him, as a testimonial of our appreciation of the great work he has accomplished, and as a token of the love and esteem we have for him. That this resolution be spread on on the records of the Society and an engrossed copy thereof be presented to Colonel Orton.

Done in Convention at Columbus, Ohio, February 23, A. D. 1921.

FORREST K. PENCE, *President*
CHARLES F. BINNS, *Secretary*
WM. D. GATES, F. W. WALKER, STANLEY G. BURT } *Committee*

Professor Orton's Letter of Acknowledgment

MY DEAR GATES:

The resolution has arrived and I was utterly unprepared for the beautiful work of art which has been prepared for me by yourself and your fellow committee men. I did not take the thing seriously at the time of the passage of the resolution thinking that it was just a momentary expression of good will on the part of my old friends, and that what I should receive would be a neatly written or possibly engrossed copy of it, but I never dreamed of the committee taking the time and trouble to prepare the beautiful and enduring testimonial which I have received, and am deeply moved by it in consequence of its unexpectedness. I shall keep it as long as I live, and it will be one of my dearest possessions. That and my Distinguished Service Medal which I won in the War and which I feel has given the stamp of approval of my military life, as this certificate gives the stamp of approval to my professional and technical life through a period of nearly a quarter of a century. The best efforts that I can make to thank you and the Committee and the Society will be utterly impossible, inadequate and unavailing, and so I shall not try, only say that I am doubly paid for whatever I have done for the American Ceramic Society from the fact that what I did was a pleasure and its own reward at the time.

With affectionate regards, I am

Yours very truly,

EDWARD ORTON, JR.

ORIGINAL PAPERS AND DISCUSSIONS

HUMIDITY SYSTEM OF DRYING TERRA COTTA[1]

By F. B. Ortman and H. E. Davis

ABSTRACT

A brief discussion of the theory of humidity drying is followed by a description of the construction and operation of a five room dryer installed above a tunnel kiln and supplied with automatic temp. and humidity control and air circulation. As compared with the older system having controlled air circulation only, the new dryer has been found to have the following advantages: (1) Reduced steam consumption; (2) 50% reduction in floor space; (3) 50% reduction in drying time; (4) Reduction in labor costs owing to elimination of a second handling of incompletely dried pieces; (5) Reduced losses from cracking and warping.

Introduction

The principles of humidity drying as applied to clay wares was first brought before the Society, in Volume 11, by Mr. E. D. Gates. His report dealt only with experimental data, but the results were promising and the principle the same as is applied in present day humidity dryers.

The next presentation of the subject was by Mr. W. A. Denmead, who went quite thoroughly into the subject in conjunction with certain manufacturers of drying equipment. After a very thorough search into the possibilities of humidity drying for clay wares, especially for tight porcelain bodies, his conclusions were all very favorable.

Instances were cited where the drying time was reduced from one month with losses, to 12 hours with practically no losses. The principle is the same as that applied in our dryer so we will not go into a discussion of it now, as it is brought out very fully in succeeding paragraphs.

[1] Received April 7, 1921.

Theory of Humidity Drying

Fundamentally, the successful drying of all hygroscopic materials, regardless of their nature, follows a definite theory which may be set forth as follows:

Consider a mass of any size and any thickness containing moisture uniformly distributed. Several considerations must be taken into account in order to accomplish its successful drying. In the first place, there must be a heating up period, during which no evaporating or drying is permissible.

This heating up period accomplishes two things. First, it heats the ware uniformly throughout its entire mass, and second, it increases the vapor tension of the moisture contained. This can not be accomplished with dry, hot air, therefore, high relative humidities must be maintained during this period.

After the material has been heated up and the vapor tension in the moisture has been raised to approximately the same as that of the surrounding air, the relative humidity of the surrounding air is gradually decreased, by increasing the temperature, and the drying period now begins.

The transfer of moisture from air to materials, or from material to air, depends upon the difference between the vapor tension of the two. If the vapor tension in the air equals that in the material, there can be no transfer of moisture in either direction. Hence, by gradually decreasing the relative humidity of the surrounding air, the vapor tension *difference* between air and material creates a condition that permits the regulated amount of moisture absorption by air from material.

Evaporation of moisture from the surface of the material, exerts a decided cooling effect, which lowers the vapor tension of the surface moisture and since, therefore, vapor tension tends to equalize wherever there is a difference, this automatically creates a condition which causes a transfusion of moisture from the interior of the piece to the surface. By gradually lowering the vapor tension of the surrounding air, this process of moisture transfusion from the center of the mass to the surface of the mass continues until the vapor tension throughout the entire mass is equal to the vapor tension of the surrounding air.

With equipment able to maintain these fundamental conditions there can be no unequal shrinkage or stresses and consequently, no warping or checking. Contrast the above with the old method of drying, where hot, dry air is blown directly against the piece, which is still cold. The effect of hot, dry air is to evaporate the moisture from the surface of the piece very rapidly, reducing the porosity and causing case-hardening. In addition to this, since evaporation means cooling and since rapid cooling and shrinkage takes place only on the surface of the mass, a condition is created that tends to check and crack the ware, and by reason of unequal strains set up, tends to promote warping. Furthermore, the old method prolonged the total drying period, since the case-hardening of the surface and resultant lower porosity of the material at this point, serves to imprison the water in the interior of the piece and to delay its transfusion to the surface where it can be picked up by the air.

Installation

The installation described below is that of the Northwestern Terra Cotta Company at Chicago. It consists of five rooms each 34 ft. long, 23 ft. 8 in. wide and 8 ft. 6 in. high, with a capacity of approximately 20 tons, wet weight. In the construction of these rooms, particular attention was given to making them as nearly air-tight as possible, and also to protecting all interior surfaces against possible deteriorating effect of humid atmosphere. Each room has one outside exposed wall. To guard against possible condensation, this wall is constructed of 13 inches of brick, 1 inch air space, 3 inches of hollow tile and 1 inch of hard cement plaster. The side and end walls and ceiling are also finished with 1 inch hard cement plaster, all of which is finally treated with 2 coats of clear minwax waterproofing.

Each box has two openings, 12 ft. wide, for loading and discharging. The doors are one piece, 3 ply, tin-clad fire doors and are handled on special patented hardware furnished by the Dry Kiln Door Carrier Company. By means of this device, the door when in place, rests with its entire weight against the jambs and lintel of the opening, reducing leakage to a minimum. When not in use, the doors may be lifted with great ease and swung clear of the wall and rolled to one side on an overhead track. (See figure 1.)

The rooms are laid out in 2 pairs and one single room. The equipment, consisting of fans, heater coils and control instruments, is located between the rooms of each pair and at the end of the single room. Each pair of rooms is served by one equipment with a separate equipment for the single room. The supply ducts and return ducts are located between the ceiling and roof beams.

FIG. 1.

All of the dry rooms are located directly over the Dressler Tunnel Kiln now in operation at the same plant. This is of considerable advantage by reason of the fact that the concrete floor of the dryer is always kept warm from the radiated heat of the kiln. (See figure 2.)

The apparatus for these rooms consists essentially of a bank of low pressure pipe coil heaters, and a separate bank of high pressure coil heaters and fan, especially designed galvanized iron duct distributing supply and return system, together with the necessary

fans and Carrier ejector nozzles for recirculating the air within the room. The return air duct system returns air to the return end of the heaters. There is also a steam spray jet situated in front of the high pressure coil heaters, and a temperature and

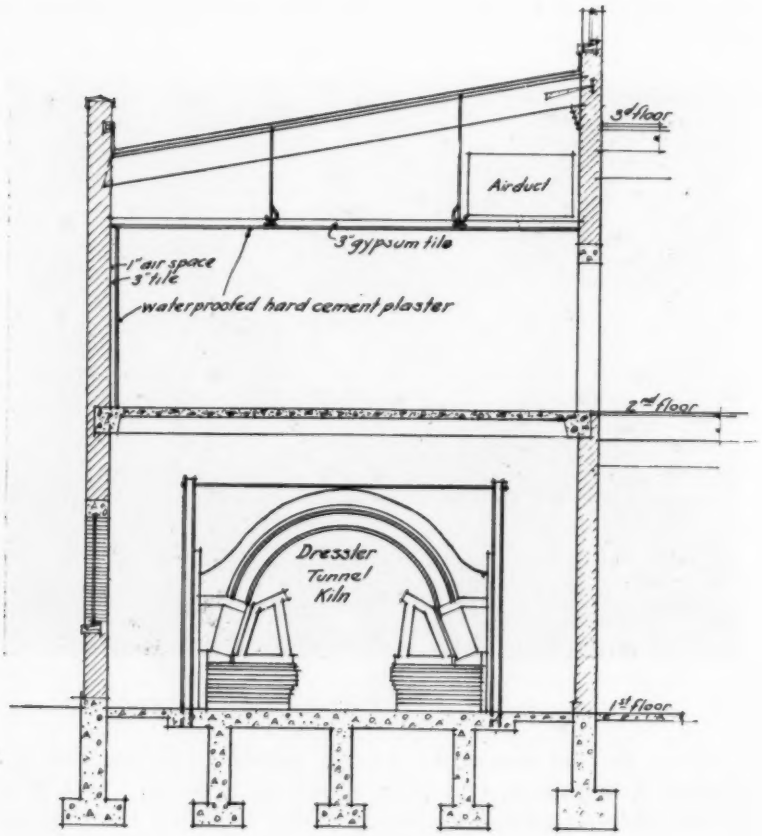


FIG. 2

humidity control system for controlling the temperatures throughout the drying stage and the relative humidity during the first heating up stage. Figure 3 shows the ejector nozzles.

Operation

Each of these rooms was designed to effect the removal of 5700 lbs. of water from a total of 40,000 lbs. of material, wet weight. This approximates 20% of moisture content, based upon the dry weight. The material is dried to approximately 5% moisture content, so that a total of 17% moisture, as compared with the dry weight, is removed in drying.

The schedule upon which these rooms are worked is as follows: Three hours are allowed for the loading of the rooms. The material is loaded in tiers and handled in and out of the rooms by means of an industrial lift truck. Eighteen hours' time is allowed for the period of drying and three hours allowed for unloading the room.

FIG. 3.

After the material is loaded in the room the low pressure coils are turned on and the fan started up. All other operations during the period are entirely automatic. The control is effected by means of hygrostats and thermostats set for given conditions, which operate through the medium of compressed air on diaphragm valves, which in turn operate on heater coils or steam spray jets as the case may be. The compressed air is supplied from a small central air-compressor plant.

The circulation of the air within the room is accomplished by means of the ejector nozzles as follows; Air from the fan is forced through these nozzles, at a very high velocity, causing an ejector effect on the air within the room, picking it up and mixing it with the hot air direct from the heater, and continually recirculating

it through the material. In order to facilitate the recirculation, a space is left between the material and the front and rear walls and ceiling. The effect is to produce practically a uniform condition of air circulation, temperature and humidity throughout the entire room.

During the first three hours, the material is allowed to heat up in an atmosphere of relatively high humidity. High relative humidity is maintained by means of a steam jet discharging directly into the air in circulation and regulated by a hygrostat. As soon as the air in circulation within the room has reached a definite relative humidity, the steam spray jets are shut off automatically. This continues until the ware temperature within the room has reached a point at which actual drying is to start. This consumes a period of approximately three hours. During this period, practically no moisture is evaporated from the material and by maintaining a high relative humidity, full advantage is taken of not only the sensible heat, but also of the latent heat to heat up the material within the room and to raise the vapor tension of its moisture so as to prepare it for drying. When a room temperature, previously determined by experiment, indicates that the ware has reached the drying temperature, a thermostat automatically shuts off the steam supply to the steam spray, irrespective of the hygrostat, and also admits steam to the high pressure steam coils. The temperature then gradually rises and the relative humidity falls off, thus creating the condition of vapor tension difference necessary for the transfer of moisture from the material to the air. This condition is allowed to continue until the safe maximum temperature permissible within the room is reached. Then a thermostat set for this temperature automatically regulates the steam admission to the high pressure steam coils and maintains a minimum temperature of 185° through the remainder of the drying period.

Further explanation of the process of drying may be had by referring to figure 4, which shows a curve obtained by plotting the difference in the wet and dry bulb temperature depressions against the time for the entire period of drying, and another curve showing the loss in weight of a sample piece placed within the dryer, for the same period.

It will be noticed that during the first three hours, no drying whatever took place. At the end of this heating up period, the steam spray was automatically shut off and the high pressure heater coils turned on, and from then on the drying proceeded quite rapidly as the depression increased (relative humidity decreased) until at the end of $14^1/_2$ hours, the testpiece was dry and lost no more weight. In accordance with the regular schedule however, the drying was continued for the entire 18 hour period to insure complete drying of all pieces in the box.

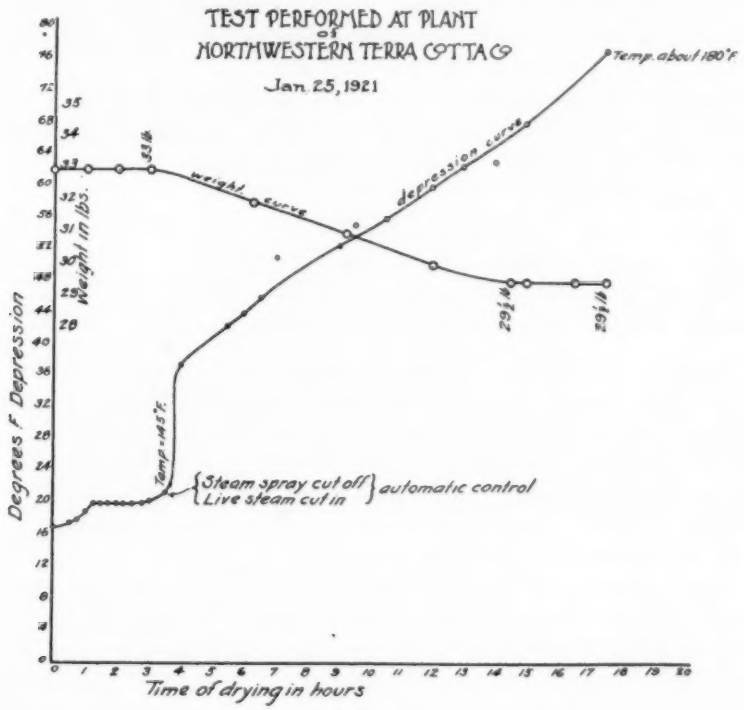


FIG. 4.

Results

Several months' operation of the above system has shown in general the following results, in comparison with the former system, where the air was admitted at one end of the box and taken

out at the other and returned to the fan without any temperature or humidity control.

First: Steam Consumption.—From actual test, the steam consumption has been found to be less than 2.4 lbs. of steam for each pound of moisture removed from the material. This refers to the total steam used, that is, including the steam spray at low pressure steam and high pressure steam. This is equivalent to 760 lbs. of steam per hour, or 25.3 boiler H.P. per hour, or 1.27 boiler H.P. per ton of terra cotta per hour. While we have no reliable figures on which to base a comparison with the old method, we are convinced that the steam consumption with the new system is considerably less.

Second: Floor Space.—There is a saving of at least 50% in the floor space required to dry a given amount of terra cotta, due to the more rapid turnover and the less floor space required for green storage.

Third: Time.—Drying is regularly accomplished in 18 hours and frequently in from 14 to 16 hours, as against 36 to 40 hours in the old system. This permits a turnover of the rooms, which makes possible closer adherence to schedules.

Fourth: Labor.—It frequently happened in the old method of drying, due to variation in atmospheric conditions, steam pressure, and lack of both temperature and humidity controlling equipment, that a considerable proportion of the ware would have to be drawn from the box and reloaded, because of incomplete drying. Under the present system, this is entirely eliminated with a considerable saving in labor cost.

Fifth: Quality of Ware.—There has been a decided reduction in the number of cracked and warped pieces. In fact, it may be said that the only cracking or checking which occurs, may invariably be traced to causes other than the drying operation.

In closing, the authors wish to express their indebtedness and appreciation to the Carrier Engineering Corp., for their valuable coöperation and assistance.

NORTHWESTERN TERRA COTTA CO.,
CHICAGO, ILL.

VARIATION IN HEAT TREATMENT OF A SILICA BRICK IN THE CROWN OF A TUNNEL KILN[1]

By A. A. Klein and L. S. Ramsdell

ABSTRACT

It is possible through microscopic investigation of a silica brick to ascertain approximately the heat treatment to which it has been subjected. In this way the temperature difference between the inner and outer ends of a silica brick which had seen service in the arch of a Dressler tunnel kiln was estimated to be at least 200°.

That the mineralogical character of silica brick is subject to variation depending upon the heat treatment which the brick has undergone has been indicated by the results of investigators of this type of refractories. Most of these studies have involved the determination of the constituents of bodies which had undergone known or partially known heat treatment. Recently, however, we had occasion to reverse this process, that is, to attempt to judge the heat treatment of a silica brick from a study of its constituents.

Two samples submitted by the Jeffery Dewitt Company were examined. One of these was a wedge shaped brick which had been used in the arch of the Dressler tunnel kiln at the Detroit plant of this concern, and the other a sample of the original "Star Brand" silica brick as received from the Harbison Walker Company.

Original "Star Brand" Brick

Visually this brick resembled a similar brick from the Harbison Walker Refractories Company described by Insley and Klein.[2] It was composed essentially of a yellowish granular ground-mass which showed a slight vitreous luster with smaller areas of a dull white nature which are termed phenocrysts and which represent the original coarse quartz grains. Segregations of ferruginous material in the form of deeply colored spots vary-

[1] Received March 10, 1921.

[2] *B. S. Tech. Paper*, **124**, p. 13 (1919).

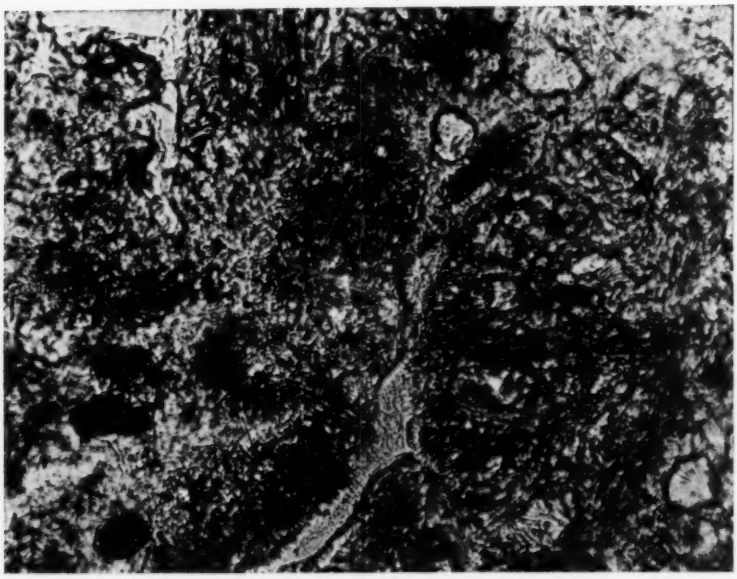


FIG. 1.—"Star" brand brick taken in ordinary light and showing shattered phenocrysts and groundmass Note the large phenocryst at the right. Magnification—200 diameters.

FIG. 2.—Same as Fig. 1 but taken in plane polarized light with crossed nicols. The light grains consist of uninverted quartz. The black predominant portion of the groundmass is cristobalite and the faint gray crystals in the groundmass are tridymite.

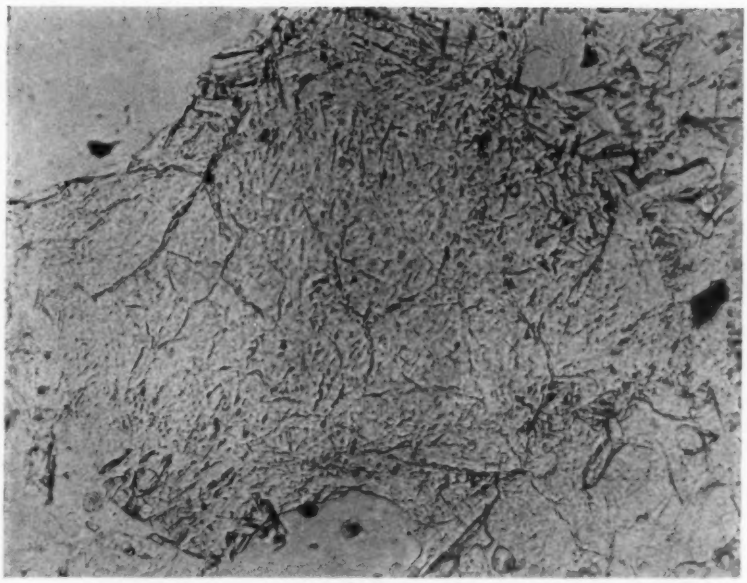


FIG. 3.—Inner end of wedge-shaped brick taken in ordinary light and showing a large phenocryst surrounded by groundmass. Magnification—200 diameters.

FIG. 4.—Same as Fig. 3 but taken in plane polarized light with nicols. Note the small irregular tridymite crystals in the phenocryst and the larger better developed crystals of the same mineral in the groundmass.

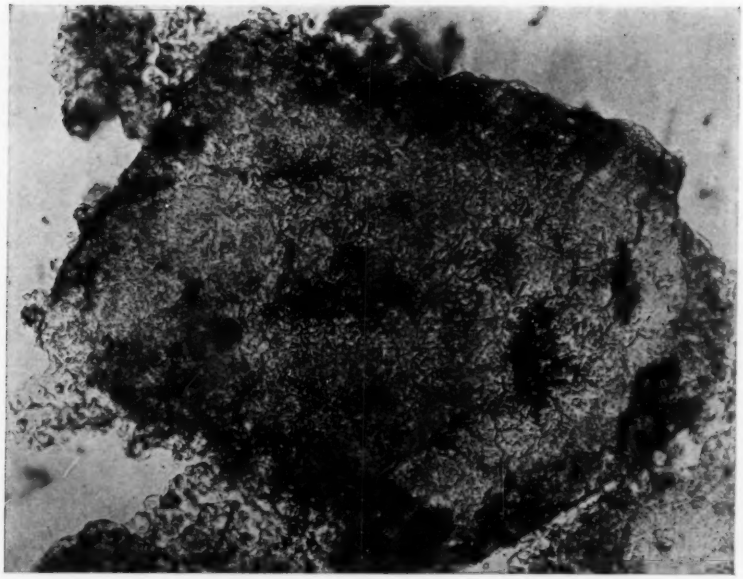


FIG. 5.—Middle zone wedge-shaped brick taken in ordinary light and showing large phenocryst as well as surrounding narrow zone of groundmass. Magnification—200 diameters.

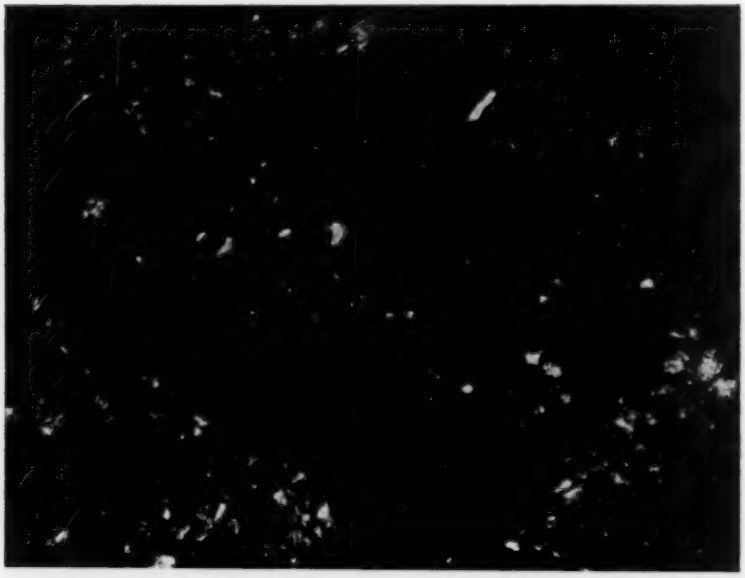


FIG. 6.—Same as figure 5 but taken in plane polarized light with crossed nicols. Note the few grains of residual uninverted quartz as well as the predominant apparently isotropic cristobalite of the phenocryst together with the tridymite crystals of the groundmass.

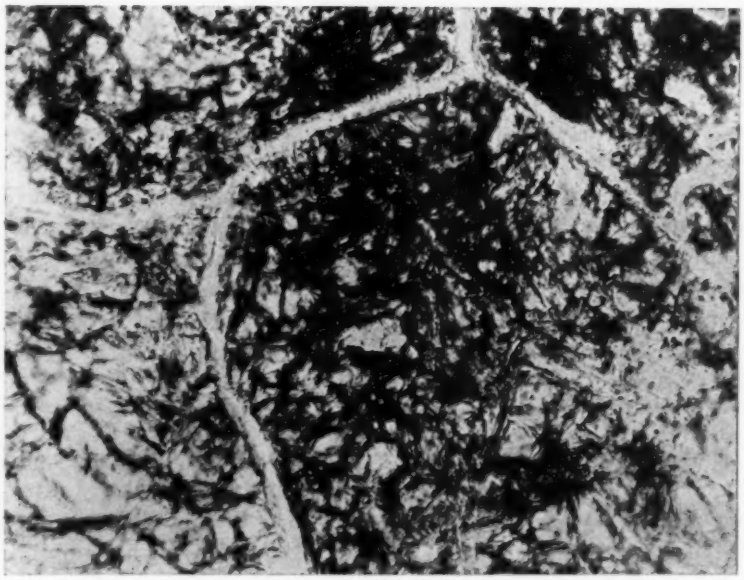


FIG. 7.—Outer end of wedge-shaped brick taken in ordinary light and showing portions of four large shattered phenocrysts together with narrow surrounding zones of groundmass. Magnification—200 diameters.

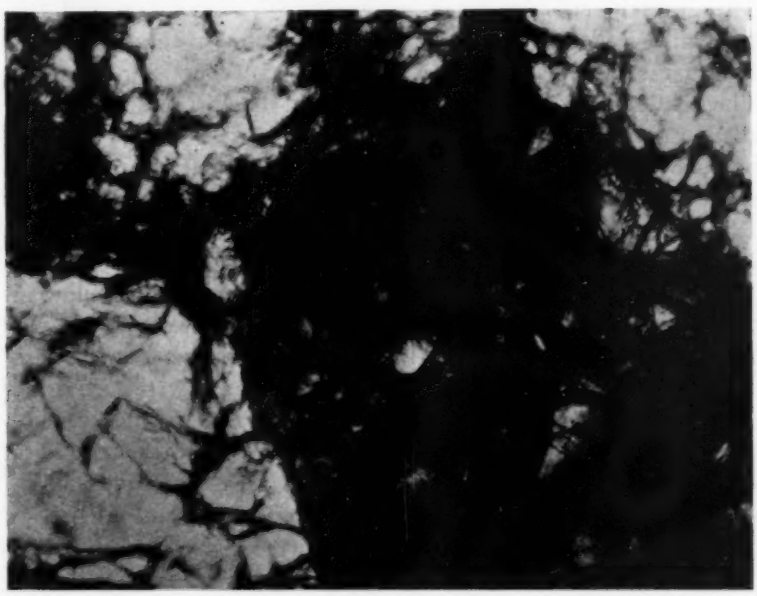


FIG. 8.—Same as Fig. 11 but taken in plane polarized light with crossed nicols. Note that the phenocrysts consist essentially of shattered quartz grains. The largest phenocryst happens to be in almost the position of extinction.

ing from red to black were also found. Microscopically the phenocrysts consisted of shattered quartz containing very little cristobalite. The ground mass consisted essentially of cristobalite and contained a relatively small amount of tridymite with practically no uninverted quartz. The amounts of the various modifications of silica present were as follows: quartz about 25 per cent; cristobalite about 55 per cent; tridymite about 20 per cent.

These data are essentially the same as those given by Klein and Insley.[1]

Wedge Shaped Brick from Crown of Tunnel Kiln

Three zones of this brick were studies, namely, the larger end (outer), the smaller end (inner) and a zone approximately intermediate between the two and referred to as the middle. Visually the material at the smaller end was deep yellow in color and notably vitreous in luster. The original dull white phenocrysts were also vitreous in luster, and grayish white to yellow in color. Microscopically the composition was found to be tridymite with a relatively small amount of cristobalite and no unchanged quartz. The ground mass contained practically no cristobalite and the tridymite crystals were relatively coarse, often-times showing the characteristic lath shaped crystals and wedge shaped twins. The tridymite of the phenocrysts could be distinguished from that of the ground mass in that the crystals were smaller and did not show the tendency toward the development of their own crystal outlines. These data resemble those given by Insley and Klein[2] for a brick which had been used in a magnesite kiln for 10 or more heats.

Visually the product from the middle zone was light yellow in color and somewhat less vitreous than the material from the smaller end. The amount of the dull white phenocrysts was also smaller. The constituents of the ground mass were tridymite and cristobalite in order of importance. The smaller phenocrysts consisted mainly of cristobalite with very little tridymite and no quartz. The large phenocrysts, however, contained a small residuum of uninverted quartz.[3]

[1] *L. c.*, Figs. 1 and 2.

[2] *L. c.*, Figs. 3 and 4.

[3] Insley and Klein, *l. c.*, Figs. 5 and 6.

The product from the large end resembled the original "Star Brand" brick, visually as well as microscopically. The large phenocrysts consisted of shattered quartz grains showing some inversion to cristobalite. The ground mass consisted essentially of cristobalite with a very small amount of tridymite.[1]

Discussion of Data

It is quite evident that the original "Star Brand" brick received a heat treatment comparable to the best American manufacturing practice. It is also very evident that there was considerable variation in the heat treatment experienced by the wedge shaped brick during its service in the crown of the tunnel kiln. The data indicate that there was a successive decrease in temperature from the small inner end to the large outer end of the brick and that the actual temperature difference was relatively great.

In view of the incomplete data concerning the effect of time and temperature on the constituents of silica brick it is impossible to translate the data into terms of temperature with absolute accuracy but a fair approximation may be arrived at.

For instance the fact that there was no further inversion of the quartz at the large end of the brick indicates that the temperature here could not have been higher than 1250°C since as shown by Insley and Klein,[2] the inversion of quartz in a cube made from a standard silica brick mix did not commence until a temperature of 1250° had been reached.

The fact that the inversion had gone practically to completion with tridymite as the stable modification at the inner side coupled with the fact that the tridymite crystals were on the whole well developed would indicate that the heat treatment here was close to, though somewhat under, the inversion point between tridymite and cristobalite, namely, 1470°. A temperature difference of at least 200°—and possibly more, is therefore indicated.

It is of further interest to point out that notwithstanding its unequal heat treatment the wedge shaped brick showed no cracking or other distinct evidence of weakening.

[1] Insley and Klein, *l. c.*, Figs. 7 and 8.

[2] *L. c.*, p. 22.

SEDIMENTATION AS A MEANS OF CLASSIFYING EXTREMELY FINE CLAY PARTICLES[1]

By H. G. Schurecht

ABSTRACT

A method is described for determining the rate of sedimentation of clays by measuring the suspended weights of a glass plummet suspended in a clay slip at different intervals of time. The specific gravity of the slip remaining in suspension may be calculated as follows: $S = \frac{P_d - P_s}{P_d - P_w}$ where S is specific gravity of slip, P_d is dry weight of a plummet in grams, P_w is suspended weights of plummet in distilled water and P_s is suspended weight of plummet in clay slip. The average weight of clay per cc. is calculated as follows:

$C_w = \frac{D(S-d)}{D-d}$, where C_w is average weight of clay per cc., D is the specific gravity of clip and d is the specific gravity of water.

It is impractical to separate by elutriation, clay particles smaller than 0.003 mm. which constitute 50–100% of many clays.

It is possible to classify particles as small as 0.0001 mm. by the plummet sedimentation method and the results are more uniform than those obtained by elutriation.

Introduction

In studying the fineness of grains of clays by the elutriation method[2] it was found that over one-half of the clays tested, contained 50–100 per cent clay finer than 0.003 mm. It is impractical to separate particles smaller than this by elutriation, since it would require several weeks of careful attention and the results obtained would be unreliable because the errors due to currents and temperature variations would be too great.

These facts have been recognized by Schloesing,[3] Sven Odén[4]

[1] Received March 11, 1921. Published by permission of the Director, U. S. Bureau of Mines.

[2] "Elutriation Tests on American Kaolins," This Journal, **3**, 355–378 (1920).

[3] T. Schloesing, *Compt. rend.*, **136**, 1608; **137**, 369 (1904).

[4] Sven Odén. *Internat. Mitt. für Bodenkunde*, **5**, 257–311 (1915); *Bull. Geol. Inst. Univ. Upsala*, **16**, 15 (1919).

and Wiegner[1] who use the sedimentation method for classifying the extremely fine soil particles in preference to the elutriation method. The separation is based upon the fact that fine particles settle slower in water than coarser particles of the same specific gravity. This is shown in Stoke's law which is as follows:

$$V = \frac{2\,D-d}{9\,\eta}\,gr^2 \text{ or}$$

$$V = Cr^2 \text{ in which } C = \frac{2(D-d)g}{9\,\eta}$$

V = Velocity of particles in cm. per sec.
η = Viscosity of the liquid.
r = Radius of particles in cm.
g = 981
d = Specific gravity of liquid.
D = Specific gravity of particles.

If a weight (P) of particles of the same size settle in a space (h) the quantity (q) deposited in the time (t) may be calculated as follows:[2]

$$Q = \frac{Pvt}{h} = \frac{PCr^2t}{h}$$

In Stoke's law it is assumed (1) that the particles (molecules) of the liquid are small in comparison with the sinking particles; (2) that the liquid is of infinite extent in comparison with the sinking particles; (3) that the particles are rigid and smooth; (4) that no slipping takes place between the particles and liquid and (5) that the velocity is small or that the radius of particles is not too large. The critical radius for quartz is about 85 μ (= .085 mm.).

C. W. Oseen[3] found that Stoke's law did not apply to particles having a high velocity and derived the following formula which applies to particles having a greater velocity as well as those having a slow velocity:

$$w = 6\,\pi\,r\,\eta\,v\,(1 + \frac{3}{8}\,\frac{dr}{\eta}\,v)$$

w = resistance of the liquid.
v = absolute amount of velocity.

[1] G. Wiegner. "Über eine neue Methode der Schlammanalyse, Die landwirtschaftlichen Versuchs Stationen," 91, 41–79 (1918).

[2] Wiegner, G., *loc. cit.*

[3] Sven Odén, *loc. cit.*

Previous Work

The apparatus used by Sven Odén in studying the sedimentation of soils consists of three parts, a glass cylinder, automatic balance and a recording apparatus. A movable plate is suspended by means of gold threads from the balance and hangs directly over the bottom of cylinder. By the settling of particles from a suspension of soil on the plate, the rate of sedimentation may be obtained by weighing the same at intervals.

For success with this apparatus, Sven Odén states that the following precautions are necessary:

"(1) The plate shall be as near as possible to the actual bottom so that no large space as regards particles shall arise under the plate; (2) the plate shall be at an approximately constant distance from the surface; (3) no clay shall collect between the plate, the wall and the real bottom of the vessel and impair the freely suspending condition of the plate and (4) convection currents within the cylinder of liquid should be prevented as much as possible."

Wiegner's apparatus consists of two glass cylinders, one wide for holding the soil suspension and another narrow, to measure the amount of clay in suspension. These cylinders are joined together, 20 cm. from the bottom of the large cylinder by means of a glass tube containing a stop cock. The large vessel is 1m. high and 3.47 cm. in diameter. The narrow cylinder is 1 cm. in diameter.

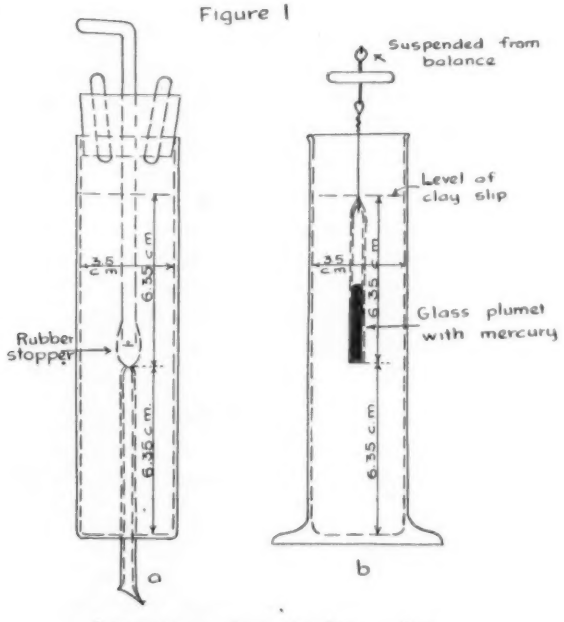
To operate, the stop cock between the two cylinders is closed, the large vessel is filled with a soil suspension and the small tube is filled with distilled water. After thorough shaking, the stop cock is opened and the meniscus in the small tube is forced up above that in the large vessel, due to differences in the specific gravities of the suspension and water. By measuring these differences the specific gravities of the suspension may be calculated at different intervals.

Although this apparatus is satisfactory for testing coarse grained soils for short periods of time, it would seem that when employed for testing fine grained clays for long periods of time, the fine particles sifting through the stop cock would cause considerable error, since it is assumed that the specific gravity of the liquid in the measuring tube is equal to that of water.

Description of Method Used

To overcome many of the objections to the above methods, the Bureau of Mines designed the apparatus shown in figure 1*b*. That shown in figure 1*a* was used to determine quantitatively the clay remaining in suspension at different intervals of time and subsequently to measure the size of grain of the particles thus removed. A comparison was thereby obtained between size of grain observed and that calculated. Also a comparison of decantation with the plummet methods (see Fig. 1*b*) was obtained.

Figure 1



Apparatus for testing the sedimentation of clays

The decantation apparatus shown in figure 1*a* consists of a cylinder containing a drain tube with an opening 6.35 cm. ($2^1/_2$ inches) above the bottom of the vessel. By means of this tube, the liquid with most of the clay particles in suspension may be decanted, although, as is explained later, many particles, on account of the

momentum obtained while settling during decantation, fall below the opening of the drain tube and therefore are not removed by decantation. To determine the amount of clay remaining in suspension at the end of 2 days, the slip is thoroughly shaken, allowed to stand for 2 days and then the suspension above the drain tube is decanted by removing the stopper from the tube. The maximum sized particles thus decanted are those which settle 6.35 cm. in 2 days. Many of the particles, therefore, have settled below the overflow tube and can only be removed by repeatedly adding distilled water, shaking and decanting at the end of two days. This decantation is carried on until all particles remaining in suspension at the end of 2 days are removed. Decantations are also made at shorter intervals of 1 day, 7½ hours, 3 hours, 1 hour, 30 minutes, 15 minutes, 10 minutes and 5 minutes.

In figure 1*b* is shown the apparatus used for measuring the sedimentation by the plummet method. This consists of a glass cylinder 15.5 cm. high and having a diameter of 3.5 cm. A slip containing 1 part clay and 5 parts water is used for the tests. Sufficient NaOH is added to produce maximum deflocculation and the slip is shaken for 8 hours previous to the test.

The plummet consists of a closed glass tube half filled with mercury, this is sealed to a thin copper or gold thread with which it is suspended from a chemical balance. Owing to the fact that the suspended weight is greater with a low clay content than with a high clay content, the variations in specific gravities of the upper half of the slip may be calculated from the suspended weights of the plummet. The plummet method of determining the specific gravities of slips is accurate to 0.0001 g./cc.

To operate, the cylinder is filled to a level equal to 12.70 cm. above the bottom when plummet is in place. It is then thoroughly shaken and placed underneath a balance. The plummet is slowly lowered into the slip, weighed, and record made of the time when the test started and when weights are taken. The weighings are repeated at the following intervals: 1, 2, 3, 5, 10, 20, 35 and 60 minutes; 2, 3, 5 and 7 hours and 1, 2, 3, 5, 10, 15, 20 and 30 days. For many clays, weighing after 5 days is unnecessary since practically all of the clay has settled although some of the finer clays will remain in suspension after 30 days.

After the first 7 hours, the plummet is removed from the cylinder containing the clay suspension and the cylinder is closed tightly with a rubber stopper. To maintain uniform temperature, the cylinder may be stored in a well insulated box. For the next weighing, the plummet is slowly immersed in the suspension and the suspended weight is taken. The plummet is again removed and the cylinder stoppered until the next weighing. By this method a large number of samples may be tested with one balance and one plummet. This test may be made automatically by using an automatic balance.

On account of the fact that different clays have different specific gravities and different shaped grains, the size of the grain of the particles remaining in suspension will vary with different clays. The size of grain of the particles remaining suspended after different intervals may be determined by carefully removing the plummet and catching a drop of the adhering slip on a microscope slide for examination, being careful not to remove too much slip.

Having determined the suspended weights at different intervals of time, the amount of clay remaining in suspension may be obtained quickly by means of charts as follows:

$$S = \frac{P_d - P_s}{P_d - P_w} = \frac{\text{Wt. of slip equal to volume of plummet.}}{\text{Wt. of water equal to volume of plummet.}}$$

S = Specific gravity of the slip.
P_d = Dry weight of plummet in grams.
P_w = Suspended weight of plummet in distilled water in grams.
P_s = Suspended weight of plummet in slip in grams.

Since $P_d - P_w$ is constant for each plummet, the values of S for different values of $(P_d - P_s)$ may be plotted on a chart as a straight line. With this chart the values of S may be readily obtained from $P_d - P_s$.

The average weight of clay per cc. is then obtained from the following formula:

$$C_w = \frac{D(S-d)}{D-d}$$

C_w = Average weight of clay per cc. of slip.
D = Specific gravity of clay.
d = Specific gravity of water.
S = Specific gravity of clay slip.

Figure 2

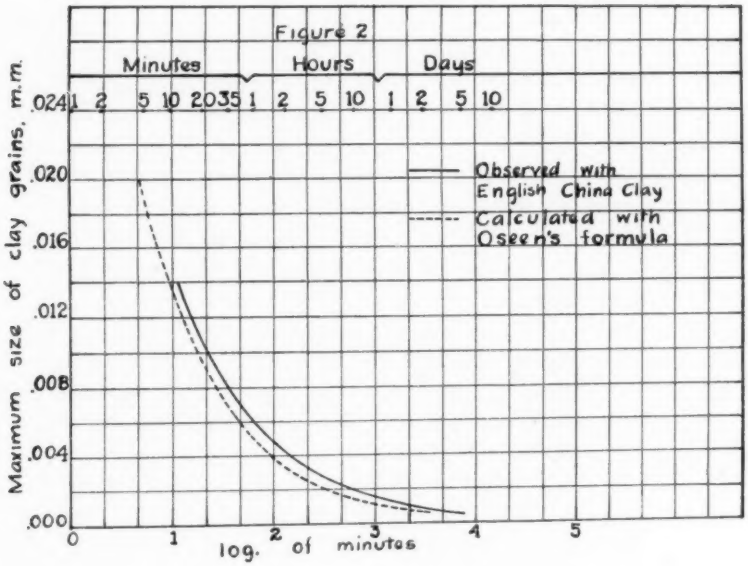
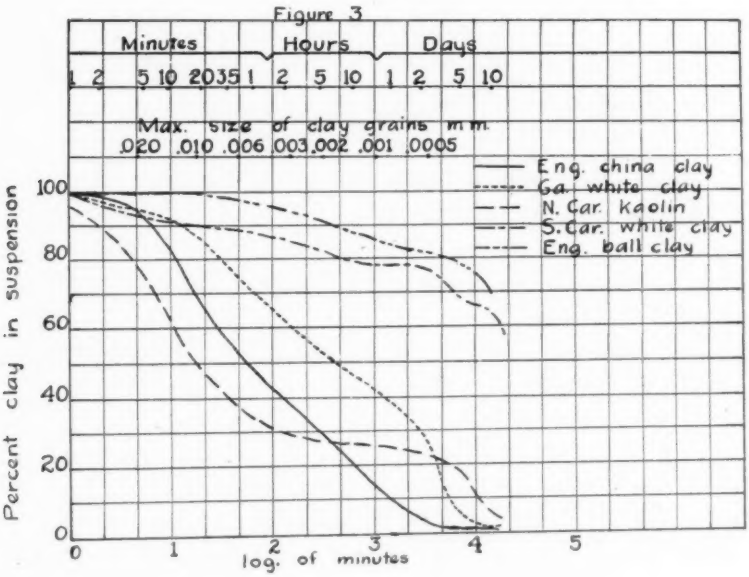


Figure 3



Assuming that $d = 1$ for water, the following formula is obtained:

$$C_w = \frac{D(S-1)}{D-1}$$

Since D is constant for a given clay, the values for C_w for different values of S may be plotted on a chart as a straight line. With this chart the values of C_w may readily be obtained. It is advisable to determine the specific gravity of each clay tested since these vary between 2.5–2.7.

Results

The results of the decantation tests are shown in table 1 and figure 2. In table 1 are shown the percentages of clay removed by decantation at different intervals.

In figure 2 are shown the maximum sizes of clay grain of English china clay in suspension for different intervals of time. In both figures 2 and 3, the logarithm of the time in minutes is plotted for convenience in order to shorten the curve. These are slightly higher than those calculated according to Oseen's formula, probably due to the fact that English china clay grains are flat and for this reason their observed diameters, as determined by a micrometer eye piece, would appear larger than the average diameter.

TABLE I.—RESULTS OF DECANTATION TESTS ON CLAYS

No. times	2 days	1 day	7½ hrs.	3 hrs.	1 hr.	30 min.	15 min.	10 min.
1	.570	.465	.550	.585	.675	.575	.600	.300
2	.510	.375	.490	.500	.590	.500	.500	.260
3	.450	.290	.425	.355	.525	.430	.380	.230
4	.390	.210	.355	.285	.450	.375	.325	.200
5	.340	.160	.300	.240	.385	.325	.260	.175
6	.290	.130	.245	.200	.335	.290	.215	.155
7	.245	.115	.200	.160	.285	.250	.175	.140
8	.200	.110	.165	.135	.240	.215	.145	.120
9	.150	.090	.130	.115	.200	.190	.130	.110
10	.100	.080	.100	.095	.165	.160	.120	.100
11	.050	.070	.080	.080	.150	.140	.105	.090
12		.060	.070	.065	.135	.120	.100	.075
13		.055	.065	.060	.115	.110	.095	.065
14		.050	.060	.060	.095	.100	.085	.050
15		.050	.060	.060	.090	.100	.050	.085
Total	3.30	2.32	3.295	3.09	4.635	3.88	3.325	2.125
Per cent	9.34	6.55	9.30	8.74	13.10	11.00	9.40	5.96

TABLE II.—A COMPARISON OF RESULTS OBTAINED BY THE PLUMMET AND DECANTATION METHODS

Time	Plummet Method		Decantation Method.
	Specific gravity of silp	Av. clay content in suspension, grs. per cc.	Av. clay content as removed by decantation., grs. per cc.
10 min.	1.083	.1320	.0575
15 min.	1.075	.1210	.0535
30 min.	1.061	.0980	.0455
1 hr.	1.047	.0695	.0380
3 hrs.	1.036	.0555	.0282
7½ hrs.	1.025	.0390	.0211
1 day	1.015	.0250	.0137
2 days	1.0033	.0075	.0077

In table 2 are shown the results obtained by the plummet and the decantation methods. With the exception of the clay remaining in suspension at the end of two days the results obtained by decantation are much lower than those obtained by the plummet method. This may be due to (1) the washing away of electrolytes by repeated decantations; (2) particles dropping below the drain tube while the slip is being drained due to the momentum in settling; (3) the fact that the area of the opening in the drain tube is very small in comparison with that of the diameter of the cylinder and (4) the removal of the fine clay in decantation, which reduces the resistance to the settling particles in subsequent decantations, thus causing the particles to fall at a higher speed.

In figure 3 are shown the results of the sedimentation tests made by the plummet method. It is obvious that comparable results may be obtained by this method. For example, by following the dotted line through 0.010 mm., we find that English ball clay has the highest per cent of clay substance (*i. e.*, $<.010$ mm.). The other clays follow in the following order: South Carolina clay, Georgia white clay, English china clay and North Carolina kaolin. In examining the curve representing the material in suspension after 10 days, it is seen that North Carolina kaolin has more material in suspension than the English china clay.

The advantages of the plummet sedimentation method as compared with the elutriation method for classifying extremely fine clay particles are as follows:

1. It permits a separation of the extremely fine clay particles (below 0.003 mm.) which constitute the bulk of many clays. It is impractical to separate particles smaller than 0.003 mm. by elutriation and the elutriation test therefore classifies only the coarse material.

2. It is much easier to maintain a uniform temperature in the sedimentation method since the volume of water is comparatively small and the apparatus may easily be stored in well insulated receptacles. In large elutriation cans, convection currents result from one wall of the laboratory being colder than the other, causing considerable error.

3. In the elutriation method it is very difficult to maintain maximum deflocculation throughout the test since the added electrolyte is continually being washed away. In the sedimentation (plummet) method, the electrolyte content remains constant throughout the test.

4. The sedimentation test is much more rapid. Ten tests may be made by this method in the time necessary to make one by the elutriation method.

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THE APPLICATION OF HEAT IN CERAMICS

By Gerald Fitz-Gerald

ABSTRACT

After discussing the relation of draft to heat transfer and kiln dimensions the conclusion is reached that the higher the flame temperature in the kiln the more economical will be the firing operation, and that a combination of natural and mechanical draft makes an ideal installation.

Scope of the Paper.—In a discussion, published in the November, 1920 issue of the JOURNAL, the comparative merits of artificial and of natural draft were briefly considered. It is the purpose of the present paper to take up the application of artificial draft with gaseous or liquid fuels. The same conditions hold good for solid fuels, but the work considered in this paper was done with fluid fuels only. Some of the theory of the draft and its relation to the heat application will be first taken up and the paper will close with some data on the results obtained.

Equipment Used.—The material for this paper was obtained by observation on a down draft kiln of rectangular construction fired with both natural and artificial draft and with both liquid and solid fuels.

The natural draft equipment for gas consisted of the common type of atmospheric burner, used on kilns wherever natural gas is available. The artificial draft equipment for both gas and oil consisted of a motor-driven low pressure air blower, which supplied the air for combustion for both gas and oil and, when burning gas, mixed the gas and air together before delivering the resultant mixture to the kiln.

Character of Heat.—Heat is evolved as the result of the combination of the fuel with the oxygen of the air. It is impossible however, to consider the heat entirely apart from the material that contains it, that is, the products of combustion. In order to consider these in detail, we must first consider the appearance of a flame, preferably a gas flame, as it is more easily studied than is an oil or coal flame.

When the flame is confined within a kiln, its appearance is, in general, characteristic of its properties. Thus the yellow flame of current practice is a reducing flame. When, however, the kiln gets so hot that the flame disappears altogether, we are left in doubt as to whether or not the flame is reducing, neutral or oxidizing. In ceramic work in general, a slightly oxidizing atmosphere is to be preferred. Sometimes however, it is necessary, more especially towards the end of the burn, to change from an oxidizing atmosphere to a reducing atmosphere in order that combustion may take place in all parts of the kiln and bring them up to the same temperature. This brings us to a consideration of the character of the products of combustion and their movement within the kiln from a physical standpoint.

Heat Travel.—In order to make the matter as clear as possible, I have likened the flow of gases through the kiln to that of a stream of water. Starting at a high temperature and at some degree of pressure, the gases flow through the kiln, losing both pressure and temperature as they go. This stream of gases has a certain volume which it is interesting to estimate however roughly. It is known that one cubic foot of natural gas requires for complete combustion approximately ten cubic feet of air, which gives eleven cubic feet of mixture. On ignition the eleven cubic feet expand quite suddenly to about sixty cubic feet. It is therefore plain that if the kiln is burning 1000 cubic feet of natural gas per hour, we have a stream flowing through the kiln, the volume of which is 60,000 cubic ft. per hour.

Consider a kiln about 10 feet square. This kiln has an area of 100 square feet. The speed of the gases through this kiln will be the volume divided by the area, which gives us ten feet per minute. As the kiln is 10 feet long the gas remains within it for one minute only. If, however, the kiln were 5×5 instead of 10×10, the gases would remain in it only 15 seconds or, in other words, the kiln would have to be 40 feet long for the gases to remain one minute.

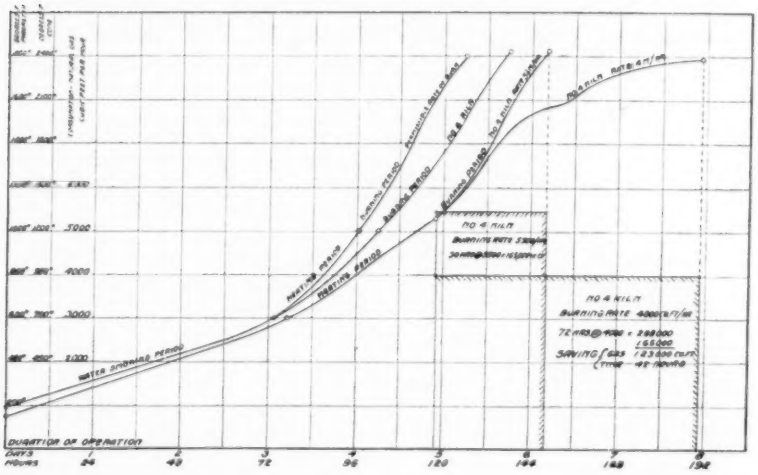
The theoretical flame temperature of the fuels in question is between 4000 and 5000 degrees F. This temperature is reduced by expansion and by deferred combustion, but 2500–3000 degrees F can be attained without trouble. It should be remembered that a high initial temperature is favorable to heat transmission

For a given kiln the speed of travel of the gases is constant for a given rate of consumption. It is therefore evident that other things being equal, the higher the initial temperature of the gases, the more economical will be the absorption of heat by the ware.

In order to attain this high initial temperature, the burner equipment should be of ample size. It should also bring together as intimately as possible the fuel and the air required for combustion. With gas fuel this is generally attained by mixing the gas and the air together before they leave the nozzle of the burner. With oil fuel this is attained by atomizing the oil into as fine a spray as possible, and supplying all the air necessary for combustion through the nozzle, with the spray.

Transfer of Heat.—I have likened the flow of gas through the kiln to that of a stream or river. A more exact comparison is that of a Pelton wheel, or over-shot wheel, located on a mountain stream.

In the water power installation we have the reservoir; the



flume; the intakes, or stand pipes; the nozzle in which the potential energy of the water head is transformed into kinetic energy; and the wheel that absorbs the energy from the water in a very brief space of time lasting hardly more than one or two seconds.

In the kiln installation we have the fuel pipes leading the fuel and the necessary air up to the burner in which the fuel is brought

into close and intimate contact with the air; the nozzle directing the stream of mixture; the fire box in which the potential chemical energy of the fuel is transformed into the thermal energy of the products of combustion and finally the ware in the kiln absorbs the energy of the products of combustion, as the Pelton wheel in its housing absorbs the energy of the water.

The curve of operation is practically the same in each case. The power curve, of course, will vary, as more or less energy is absorbed. So will the heat curve of the burnt gases vary from the lighting up of the kiln until its shutting down. At first the absorption will be pretty rapid as the differences in temperature between the ware and the gases is great but the curve will gradually flatten out as the temperature of the ware increases and as the temperature head decreases.

A complete study of the temperature curve of the burnt gases would include the action of the recuperators if these are used. A recuperator may be likened to the suction pipe from the turbine in that it seeks to absorb as much energy as possible after the gases have left the kiln and after the water has left the turbine.

Conclusions

It is evident that the successful application of heat to the ware in the kiln depends on the means adapted to make the application.

Natural Draft.—Natural draft is generally adopted as it is always available and is free from mechanical breakdown. It can be very efficient if the complete installation is well designed, which unfortunately is seldom the case and so in most cases natural draft does not get a fair show.

Mechanical Draft.—Mechanical draft when installed is always designed for the case in hand and consequently is in most cases more efficient than natural draft. While subject to mechanical breakdown, it is not subject to loss of efficiency due to atmospheric disturbances.

Combination Natural and Mechanical Draft.—A combination of natural and mechanical draft is a happy solution of the problem. The mechanical apparatus is generally applied to overcome the deficiencies of the natural draft system already existing. This is quite frequently the case in solid fuel-burning in-

stallations. In the case of fluid fuel, either gas or oil, the apparatus also serves another purpose—that of bringing the fuel and the air required into intimate contact.

Capacity.—Other conditions being equal, the apparatus having the greatest capacity is apt to prove the most economical. This sounds like a paradox, but is only another way of repeating our former conclusion of the range of operation. A practical illustration will serve to conclude this paper.

Economy.—Take a material or ware to be burnt at 2000°F Consider two sizes of the same apparatus, whether for natural or mechanical draft, one capable of maintaining 2500°F in the kiln, the other 3000°F in the kiln. Of the two the second unit is probably the most economical, for the reason that its temperature head of 1000°F is just twice as high as the head of the other (500°F), and can be maintained with less than twice the fuel consumption. On many kilns an increase in the rate of combustion of twenty five to fifty per cent, gives a fuel economy and a time saving of twenty-five per cent each.

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THE PRODUCTION OF SOME WHITE ENAMELS FOR COPPER[1]

By R. R. Danielson and H. P. Reinecker

ABSTRACT

The investigation deals with the development of some white enamels for copper watch dials, thermometer scale plates, and signs. The effect of varying Na_2O, PbO, cryolite, SiO_2 and B_2O_3 on the properties of the enamels was studied in twenty enamel compositions. The following conclusions were reached: (1) Correct melting is extremely important in the preparation of copper enamels; (*a*) Slow air cooling of the frit is preferable to quenching in water. (*b*) Repeated melting tends to promote opacity and to eliminate dissolved gases. (2) A somewhat reducing atmosphere during firing avoids oxidation of the copper. (3) Slight changes in enamel composition have a decided effect on the resultant properties. (4) Sodium oxide promotes gloss but reduces opacity very decidedly. (5) Lead oxide promotes fusibility without materially reducing opacity, except by dilution. (6) Cryolite is not a desirable flux or opacifier as it tends to develop a matt finish. (7) It is desirable to keep the boric oxide content low and good enamels may be produced without it. (8) By using "white arsenic" as an opacifier tin oxide is unnecessary. (9) The following were the best enamels obtained and these appear to be equal to a number of watch dial enamels examined: C-19 and C-20. (10) A second group of compositions which appear to promote results equal to those in use for thermometer scales, advertising letters, etc., are C-10, C-21, C-22, and C-24. In selecting these compositions, all factors such as opacity, gloss, texture, fit and resistance to attack of copper have been considered.

Batch Compositions of Best Enamels—(To give 100 parts melted)

	Quartz	Feldspar	White lead	Red lead	Potass. nitrate	Soda ash	Oxide arsenic	Potass. carbonate	Cryolite	Sodium nitrate	Tin oxide	Borax
C–19	34.8	1.3	62.0	....	3.2	1.9	5.2	2.3	...	2.7	..	...
C–20	32.8	1.3	64.2	....	3.2	1.9	5.2	2.3	...	2.7	..	...
C–10	30.0	...	58.0	....	2.4	4.3	5.5	5.0	7.5	...	..	...
C–21	30.8	1.3	66.5	....	3.2	1.9	5.2	2.3	...	2.7	..	...
C–22	31.0	...	....	48.3	3.2	2.3	5.5	...	...	4.1	10	4.1
C–24	31.0	...	....	49.8	3.2	3.4	5.5	...	...	4.1	10	...

[1] Received June 16, 1921. By permission of the Director, Bureau of Standards.

The literature of the American Ceramic Society is decidedly lacking in information regarding the enameling of sheet copper, a business which is taking on considerable importance in line with the development of the other branches of the industry. Only one paper on this subject can be cited, a treatise on art enameling.[1] This work, however deals only with clear glass enamels of the cloisonne type and has not undertaken the development of white enamels of the type used for watch dials, thermometer scales and name plates.

Aside from this reference the few text books on the subject are so vague and lacking in details of technique that they are of little assistance to one attempting the development of enamels for copper.

The Bureau of Standards has had repeated requests for information relating to this type of enamel. It was therefore decided to carry on a limited investigation to develop a few compositions of commercial value and at the same time gather information as to the possible variations in ingredients and the effects on the enamels. In carrying on the work considerable information was obtained regarding the technique of copper enameling which was found in some respects to differ widely from that of sheet steel enameling.

The brief nature of this investigation made impossible the study of a large number of compositions laid out in a systematic fashion but it is believed the general results and conclusions will be of value to those interested in this type of enameling.

Two copper enamels which were reported as having given satisfactory results were considered as a basis for the investigation. The melted compositions of these enamels are as follows:

	A	B
SiO_2	38.0	31.5
PbO	51.4	44.7
CaO	0.4	....
Na_2O	1.5	5.4
K_2O	3.4	1.5
As_2O_3	5.3	5.5
SnO_2	...	9.9
B_2O_3	...	1.6

[1] "Art Enameling on Metal," by J. Minneman, *Trans. Amer. Ceram. Soc.*, **13**, 514 (1912).

Based on the average of these compositions, 20 enamels have been prepared. The batch compositions are given in table 1, and the percentage compositions in tables 2–5.

Preparations of Enamels

The enamels were prepared in the usual manner by weighing 4.5 pound samples, mixing thoroughly by hand and then smelting in crucibles in a gas fired crucible furnace. The time required to melt the batches to a clear molten enamel varied from 30 to 50 minutes, when the enamels were chilled by cooling in water. The frits were then dried and ground dry in porcelain ball mills until they passed an 80-mesh sieve.

It was soon noted, however, that some of the enamels did not have the opacity which might be indicated by their compositions so the smelting was repeated, using a method foreign to that in use in ordinary enameling processes but apparently advocated by makers of copper enamels. Under this latter method, the melted enamels are cooled by casting on an iron slab, then melting is repeated by returning the chilled enamel to the crucible. The process is repeated a number of times, three meltings being accepted in our work. The beneficial results of this remelting were soon apparent for the enamels produced were much more opaque than those chilled in water and it was also noted that there was less tendency for the enamels to blister and develop pinholes.

This phenomenon of increased opacity is undoubtedly due to two factors. Reheating of glasses containing such ingredients as arsenic oxide tends to increase their opacity due to the precipitation of the arsenic in the glass. Further, the remelting tends to produce more opaque enamels in reducing the tendency to "oversmelt." It apparently is much easier to eliminate the gases by subsequent reheatings than it is to drive these off at one initial heating and at the same time retain the necessary ingredients which serve as opacifiers.

Application and Firing of Enamels

The copper plates used in the investigation were 2″ x 3″ in size and of 22 gauge metal. They were prepared by boiling in an al-

The literature of the American Ceramic Society is decidedly lacking in information regarding the enameling of sheet copper, a business which is taking on considerable importance in line with the development of the other branches of the industry. Only one paper on this subject can be cited, a treatise on art enameling.[1] This work, however deals only with clear glass enamels of the cloisonne type and has not undertaken the development of white enamels of the type used for watch dials, thermometer scales and name plates.

Aside from this reference the few text books on the subject are so vague and lacking in details of technique that they are of little assistance to one attempting the development of enamels for copper.

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TABLE 1.—BATCH COMPOSITIONS OF COPPER ENAMELS

To Give 100 Parts Melted

	Quartz	Feldspar	White lead	Red lead	Potass. nitrate	Soda ash	Oxide arsenic	Potass. carbonate	Whiting	Magn. carbonate	Cryolite	Sodium nitrate	Tin oxide	Borax
C-1	30.0	...	58.0	....	9.6	17.3	5.5	...	...	...	..	...	..	...
C-2	30.0	...	58.0	....	9.6	....	5.5	...	...	...	10	...	..	...
C-3	30.0	...	46.3	....	9.6	17.3	5.5	...	...	...	10	...	..	...
C-4	30.0	...	46.3	....	9.6	....	5.5	...	...	...	20	...	..	...
C-6	30.0	...	58.0	....	9.6	8.6	5.5	...	...	...	5	...	..	...
C-7	36.0	1.3	58.5	....	2.4	2.7	5.4	...	0.4	0.4	..	...	..	...
C-8	34.0	1.3	58.5	....	2.4	6.2	5.4	5.4	0.4	0.4	..	...	..	...
C-9	32.0	1.3	58.5	....	2.4	9.6	5.4	5.4	0.4	0.4	..	...	..	...
C-10	30.0	...	58.0	....	2.4	4.3	5.5	5.0	...	...	7.5	..	..	...
C-12	35.0	1.3	58.5	....	2.4	4.4	5.4	5.4	0.4	0.4	..	...	..	...
C-13	31.0	...	....	46.0	3.2	6.8	5.5	...	...	...	..	4.1	10	...
C-17	32.2	1.1	52.0	....	3.75	1.6	4.6	2.7	...	...	..	2.2	..	...
C-18	31.0	...	59.0	....	2.1	4.3	5.5	5.0	...	...	..	...	..	...
C-19	34.8	1.3	62.0	....	3.2	1.9	5.2	2.3	...	...	..	2.7	..	...
C-20	32.8	1.3	64.2	....	3.2	1.9	5.2	2.3	...	...	..	2.7	..	...
C-21	30.8	1.3	66.5	....	3.2	1.9	5.2	2.3	...	...	..	2.7	..	...
C-22	31.0	...	....	48.3	3.2	2.3	5.5	...	...	...	..	4.1	10	4.1
C-23	31.0	...	....	46.2	3.2	0.8	5.5	...	...	...	..	4.1	10	9.5
C-24	31.0	...	....	49.8	3.2	3.4	5.5	...	...	...	..	4.1	10	...

TABLE 2.—EFFECT OF VARYING FLUXES

Constant Part 80.—30 SiO_2, 40 PbO, 4.5 K_2O, 5.5 As_2O_3

Variable Part 20.—Na_2O, PbO and Cryolite

	Variables				Remarks			
Enamel	Na_2O	Cryolite	PbO	SiO_2	Opacity	Gloss	Texture	Effect on copper
C 1	10.0	..	10	...	Clear glass	Very good	Pin-holed	None
C 6	5.0	5.0	10	...	Poor	Good	Pin-holed	None
C 10	2.5	7.5	10	...	Good	Fair	Pin-holed	None
C 2	....	10.0	10	...	Very good	Poor	Pin-holed	Very slight
C 3	10.0	10.0	..	...	Good	Poor	Fine pin-holed	Slight
C 4	....	20.0	..	...	Good	Matt	Pin-holed	Attacks copper
C 18	2.5	5.5	11	1.0	Good (yellow)	Good	Crazed & wavy	Attacks copper

TABLE 3.—EFFECT OF VARYING SiO_2 AND Na_2O

Constant Part 96.—32 SiO_2, 1.3 Feldspar, 50.5 PbO, 4.8 K_2O, 1.6 Na_2O, 5.4 As_2O_3, 0.22 CaO, 0.18 MgO

Variable Part 4.—Na_2O and SiO_2

	Variables		Remarks				
Enamel	SiO_2	Na_2O	Opacity	Gloss	Fusibility	Texture	Attack on copper
C 7.....	4.0	...	Fair	Good	Refractory	Wavy	Slightly attacks
C 12.....	3.0	1.0	Poor	Good	Refractory	Wavy	None
C 8.....	2.0	2.0	Glass	Good	O.K.	Crazed slightly	None
C 9.....	....	4.0	Glass	Good	O.K.	Crazed slightly	None

TABLE 4.—EFFECT OF VARYING SiO_2 AND PbO

Constant Part 94.— 30.8 SiO_2, 1.3 Feldspar, 51.5 PbO, 3.1 K_2O, 2.1 Na_2O 5.2 As_2O_3

Variable Part 6.—PbO and SiO_2

	Variables		Remarks			
Enamel	PbO	SiO_2	Opacity	Gloss	Texture	Attack on Copper
C 17.....	...	6.0	Good	Fair	Wavy	Attacks copper refractory
C 19.....	2.0	4.0	Good	Good	Good	None
C 20.....	4.0	2.0	Good	Good	Good	None
C 21.....	6.0	...	Fair	Good	Good	None

TABLE 5.—EFFECT OF B_2O_3 ON COPPER ENAMELS

Constant Part 96.5.— 31 SiO_2, 45 PbO, 1.5 K_2O, 3.5 Na_2O, 5.5 As_2O_3, 10 SnO_2

Variable Part 3.5.— Na_2O, PbO and B_2O_3

	Variable			Remarks			
Enamel	Na_2O	PbO	B_2O_3	Opacity	Gloss	Texture	Effect on copper
C 13.....	2.0	...	1.5	Poor	Good	O.K.	Attacks copper
C 22.....	...	2.0	1.5	Fair	Good	O.K.	Very slight
C 23.....	...	...	3.5	Good	Good	Chipped	Slight
C 24.....	...	3.5	...	Good	Good	O.K.	None

kaline bath and then given a mild pickling in dilute nitric acid. Following the pickling, the plates were thoroughly rinsed to remove the excess acid and then dried.

The plates were then given a very light wash of the enamels ground in water as it was found that this prevented excessive oxidation of the metal during the firing process. It was also noted that coating the backs of the plates tended to reduce buckling of the copper. The buckling would not have permitted the development of the true adhering quality of the enamel, as a slight tendency of an enamel to chip, due to strain, would have been increased by the buckling of the plate. The back of enameled copper is also usually given a light enamel in commercial practice. A layer of powdered enamel was then sifted over this wash when the plates were ready for firing.

In the preliminary work of this investigation, the samples were fired in a small electric muffle furnace. It was soon found that poor results were obtained, due, it is believed, to the slow radiation of heat from the muffle walls and the highly oxidizing conditions of the furnace atmosphere, both of which tended to excessive oxidation of the copper before the enamel had fused.

A gas fired muffle furnace with a muffle 14″ x 24″ x 18″ was substituted for the electric furnace with a great improvement in the results. Temperatures were determined with a platinum platinum-rhodium thermocouple encased in a thin porcelain protecting tube and suspended directly over the plates.

The time and temperature for firing will vary with gauge of metal, thickness of enamel coating and other local conditions, so it is sufficient to state that the temperature varied from 800°C to 950°C and the time from 45 seconds to $2^1/_4$ minutes.

Discussion of Results

To facilitate a study of the various enamels they have been arranged in four groups, in which by direct and cross comparisons, the variations in fluxes and in the refractory portion (silica and feldspar) can be studied. In table 2 is shown a group of seven enamels, arranged to show the effect of varying fluxes on the resultant enamel. The first four enamels of the group comprise a study of the effect of reducing sodium oxide with a corresponding increase in cryolite. Cryolite is not a usual ingredient of copper enamels and this study tends to explain this omis-

sion. While cryolite increased the opacity, there was a corresponding decrease in gloss such that when it comprised ten parts of the melted batch, the gloss was poor and 20 parts had produced a matt enamel. Increase of cryolite tended to promote attack of the copper and it was noted that lead oxide was also more active in attacking the copper. In comparing C 10 and C 18, the effect of reducing the cryolite two parts and increasing the silica and lead oxide each one part is shown in improved gloss. A point which was evident all through the work was the marked effect of small variations in the composition of this type of enamels, as compared with those for sheet steel and cast iron.

The effect of reduction in the silica content with corresponding increases in sodium oxide is shown in table 3. While the gloss of the enamels was good, the opacity decreased rapidly as sodium oxide was substituted for silica. The higher silica enamels were also exceedingly refractory and the tendency of Enamel C-7 to attack the copper was undoubtedly due to the necessity of subjecting this enamel to a sharp fire to properly fuse it over. This study led to the conclusion that high silica was a detriment to good copper enamels but that replacing silica by soda was not the correct method to reduce refractoriness in view of the tendency of the latter to reduce opacity.

Therefore, a group of four enamels was planned to correct the refractoriness of silica without decreasing opacity. In table 4 is shown the effect of decreasing silica with corresponding replacements by PbO. This change in composition was beneficial from all viewpoints in that refractoriness was reduced and texture and gloss were benefited. There is evident, though, in the largest increase of lead a tendency to loss of opacity. This would be expected beyond a certain limit in that lead is not an opacifier and would simply tend to decrease opacity by dilution.

Since some of the base enamels contained boric oxide, a group, table 5, showing some slight variations in this connection was tried. It was noted that soda and boric oxide in combination tended to promote attack of the copper. While the contents of boric oxide were small, it is not believed that beneficial results will be derived from the use of boric oxide in copper enamels.

Conclusions

While the number of enamels covered in this work has been small, it is believed that the conclusions summarized in the abstract can be derived from the work and that these will be of considerable assistance to those interested in the development of copper enamels.

BUREAU OF STANDARDS,
WASHINGTON, D. C.

AN OXYGEN-ACETYLENE HIGH-TEMPERATURE FURNACE[1]

By Hewitt Wilson

ABSTRACT

A detailed description, with drawing, is given to show the use of oxy-acetylene gas in a small furnace for using refractory cones. The advantages claimed, are (1) simplicity of construction, operation and repair; (2) ease of control; (3) high temperatures obtainable; (4) oxidizing atmosphere; (5) comfortable working conditions, owing to the small volume of hot combustion gases; and (6) portable character of the furnace, fuel and firing apparatus, permitting its use in localities where gas or electricity can not be obtained, such as in the field or at the mine. The following change is suggested in the Ceramic Society's specified rate of heating for cone fusion tests. "The rate of heating shall not exceed that corresponding to one-half a cone (approximately 10 degrees C) per minute within a range of ten cones below that of the final fusion cone and this rate shall preferably be decreased to one cone per five minutes within two cones of the final cone of fusion."

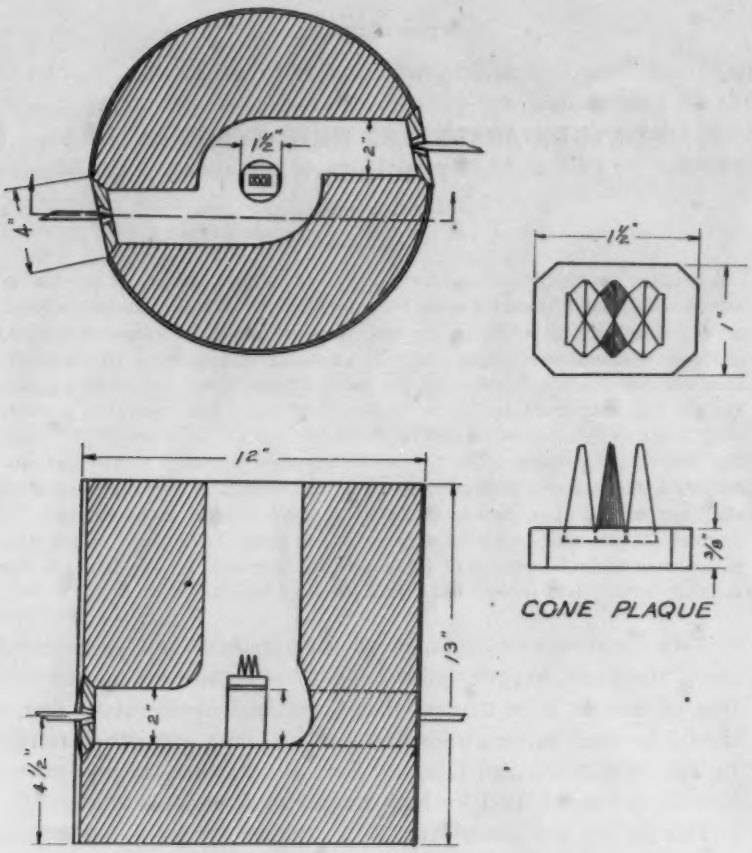
With the recent development of the apparatus and commercial use of the gases, oxygen and acetylene, for rapid welding and cutting of metals, it is natural that these high-temperature flames should be used in the fusion tests of fire clays and other refractories. Washburn and Libman[2] have shown that the oxy-acetylene flame can be used for high temperature ceramic work.

This is not the description of a "paper" furnace but of one which has given good service in the Ceramics laboratory of the College of Mines, University of Washington, in the fusion of over 500 clay samples from the State of Washington, ranging from cone 2 to cone 35.

The furnace shown in the accompanying sketch is similar to the fusion furnaces used where natural gas of high calorific value can be obtained. As the volume of the oxygen-acetylene gas

[1] Received August 6, 1921. By permission of the Director, U. S. Bureau of Mines.

[2] Washburn, Edward W., and Libman, Earl E., This Journal, 3, 634–640 (1920).



OXY-ACETYLENE
CONE FUSION FURNACE

and its products of combustion is small and the temperature of the flame is very high, the size of the furnace is relatively small. The one described can be carried in the arms.

Burners and Flame.—Two small "lead-burning" torches, placed on opposite sides of the furnace, direct the flames

tangentially to the circumference of the circular chamber.[1] The combustion gases follow the usual spiral path around the cone pedestal and out at the top. This center stand is high enough to keep the cones out of the direct blast of the flame. Uniform temperatures can be produced on all sides of the cone plaque by adjusting the burners to supply the proper amounts of oxy-acetylene and by preserving a symmetrical interior design of the fire chamber together with the centering of the cone plaque. A projecting portion of the furnace wall or a fallen particle may so deflect the flame that a local hot spot may be produced.

Lining.—For fire-clay fusion temperatures we have successfully used alundum, magnesia, and an alundum-magnesia mixture. We have had poor results with zirkite (early fusion), pure china clay (early fusion), carborundum (early fusion, accompanied by blistering and bubbling), combinations of clay and magnesia, and a clay-carborundum mixture.

For a magnesia lining, a good grade of brick may be cut and fitted into the circular jacket, or the lining may be made in the following manner. We press a prepared, calcined ferro-magnesia mixture in a mold and fire the resulting shape. This is then backed with fire clay or an insulating material and packed into a suitable container, which may be an empty can of suitable dimensions. We prepare the calcined magnesia by crushing a good grade of magnesia brick to pass a 20-mesh sieve and adding enough gum or dextrine and a small amount of water to make the mass plastic. This can be packed into position for either the original lining or for repairs. It derives its dried strength from the gum, while the fired strength may be obtained directly by heating with the oxy-acetylene flame. One magnesite brick will provide a number of cone plaque stands. After cutting to approximate size with a hammer, the stands can be rounded to dimension on an emery wheel. A thin layer of iron chromate must be daubed on the top of the stand to prevent violent reaction between the clay and magnesia above 1600°C.

Cone Plaques.—We mix raw English china clay with an equal weight of English china clay, calcined to cone 15, and ground to

[1] R. T. Stull: "New Type of Laboratory Test Kiln," *Trans. Am. Ceram. Soc.*, **12**, 127 (1910).

pass a 20-mesh sieve. The plastic mass is rolled out on a table to an approximate thickness of $^3/_8$ inch, and a small rectangular indentation formed by pressing with a suitable wooden core. The plaque is then cut to dimensions, dried, and fired to cones 2 to 4 so that it will possess sufficient strength to permit easy mounting of the cones and will stand placing in a hot furnace without disruption.

Mounting Cones.—Plastic china clay mixture is pressed into the rectangular shaped opening of the cone plaque. It is best to undercut the edges slightly so that this plastic mass will not pull out easily. Triangular holes are cut in the clay and the cones inserted with additional clay packed around them. The plaque is marked and placed in the top of the furnace, just over the flame, to dry before placing in the hot furnace. Calcined cones or cones made of calcined materials and gum arabic, and plaques made as above, can be placed in a furnace at a temperature corresponding to cones 20 or 23 without bursting or breaking. Placed as shown in the sketch, we have two duplicate unknown cones with a series of four Orton cones. These are not spaced as recommended in the specifications of the American Society for Testing Materials, but are placed as close together as possible. With calcined materials and good packing, the tendency of the cones to fall on each other is eliminated, and one is more certain of the exact cone deformation, compared with that of the standard Orton cones. By preparing cones and plaques ahead of time and preheating them on the top of the furnace, we can replace plaques of cones in the hot furnace in the minimum time.

Cost of Oxy-Acetylene Apparatus.—The familiar welding torch, pressure gauges and regulator valves so widely used for welding metals, are used. The oxygen and acetylene are shipped in tanks from the factories to any express or freight station. The oxygen tanks are loaned free of charge, while a 300-cubic foot tank for acetylene may be leased for about $75.00. The valves, gauges, regulators, hose connections, and two small lead burning torches cost approximately $105.00. A single large welding torch with the same necessary equipment costs about $140.00 and can be used in place of the two smaller torches, by cutting only a single flame entrance and placing the cone plaque on

a bridge of magnesite. In this case, the flame shoots under the bridge and rises on both sides. Oxygen costs $2.00 per hundred cubic feet and acetylene gas, $3.35. The initial outlay including 300 cubic feet of each gas, will be about $200.00. However, nearly all of the essentials for this equipment will be found in the average well-equipped machine shop or factory and may be used for this purpose.

Gas Consumption.—The following is a typical 5-hour run.

Laboratory number	Cone fused	Oxygen reading, cu. ft.	Acetylene reading, cu. ft.	Time, p. m.
Start	.....	150	226	1:10
806	31–32	125	210	2:25
807	31+	117	205	2:45
808	30	110	200	3:10
809	31	105	195	3:30
810	31–32	99	190	3:48
806	31–32	93	185	4:10
807	31+	88	180	4:30
808	30	80	172	4:45
809	31	71	165	5:10
810	31–32	59	163	5:37
KW	28	52.0	160	5:56
11 Heats	Cone 30.8 average	98 cu. ft.	66 cu. ft.	4 hours 46 minutes

Total cost of gas..... $4.17
Cost of gas per heat..... 0.38

The cost can be cut almost in two by running two *different* unknown cones on the same plaque, a procedure which is warranted when temperatures are uniform and check runs are made.

A speed test run was made, starting with a cold furnace. Cone 26 was deformed in 35 minutes with the consumption of 20 cubic feet of oxygen and 8 cubic feet of acetylene. Cone 32 was deformed five minutes later with a total gas consumption of 28 and 10 cubic feet of oxygen and acetylene, respectively. Greater economy is obtained if a number of tests are run immediately after the original heating.

The average cost of gas used in fusing 300 samples in a period from August 10, 1920 to April 9, 1921, including the experimentation and development of the furnace, was 47 cents per sample.

Time of Heating.—The specifications of the Standard Committee of the American Ceramic Society call for a rate above 800 degrees C not to exceed 10 degrees C per minute. This means about a 76-minute run to the fusion point of cone 28 in addition to the time required to reach 800 degrees C. After carefully comparing the results of first heats which approximate this specified rate, with heats made with a hot furnace, we believe that it is unnecessary to spend this much time at the lower temperatures and that the period where the slow rate of heating is essential, is within two or three cones of the final cones of fusion. If we could revise the specifications, we would consider the following an improvement.

"The rate of heating shall not exceed that corresponding to one-half a cone (approximately 10 degrees C) per minute within a range of ten cones below that of the final fusion cone and this rate shall preferably be decreased to one cone per five minutes within two cones of the final cone of fusion."

Advantages of the Oxy-Acetylene Fusion Furnace

(1) **Simplicity.**—This type has the advantage of the simple construction common to all gas or oil-heated furnaces in contrast to the carbon resistance electric furnace. In the latter type, we found difficulty in maintaining an expensive crucible protection for the cones; also, the electrical contact between the resistor and metal leads was by no means uniform or dependable after a little use. The cone plaque-stand in the gas-fired furnaces can be replaced and any holes in the walls patched while the furnace is hot. Very little time is lost for repairs.

(2) **Ease of Control.**—With a flame which can be thrown in any direction to any part of the furnace and also raised in temperature to a point above 3,000 degrees C, uniform conditions can be maintained around the cones and the temperatures held or varied at will from below cone 10 to cone 42.

(3) **High Temperatures.**—High temperatures which would be impossible with the ordinary gases or fuels of low calorific value can be produced. Studies can be made with the super-refractories.[1]

[1] Washburn and Libman

(4) **Oxidizing Conditions.**—Our best results in terms of clean colors with white, buff, and dark-burning clays have been obtained with the oxygen-acetylene flame. The use of air with its large content of nitrogen makes reducing conditions unavoidable with natural gas flames at the higher temperatures. With oxygen gas in place of the air mixture, the high temperatures can be maintained with the minimum content of reducing gases. With the carbon resistance furnaces it was impossible to keep the high-carbon gases from passing through the crucible and blackening both cones and plaque.

(5) **Comfortable Working Conditions.**—With the small volume of combustion gases rising from the furnace, it is possible to watch the cones deform with the eye at a distance of 15 to 24 inches from the top. This is impossible where the volume of the hot gases is large. In that case it is necessary to take short-time observations from behind insulating screens. With the personal discomfort removed one can maintain the firing conditions with a greater degree of nicety.

(6) **Portable Character.**—The firing equipment, fuel, and even the furnace itself, can be shipped to almost any out-of-the-way locality, factory, or mine. In prospecting a new area for fire clays or running control tests at the mine, this apparatus can be used to save time and expense. Shipments of inferior refractory material can be stopped at the clay bank or mine instead of at the distant factory. The mine foreman can tell within two hours whether a sudden change in the fire-clay seam is for better or worse without sending a sample to a distant testing laboratory.

Other Possibilities.—Hydrogen gas can be used with oxygen to produce a maximum flame temperature of 3,191 degrees C (Richards)[1] and is somewhat cheaper than acetylene and almost as universally obtainable.

Compressed artificial or natural gas fired with oxygen will give higher temperatures than air and the gas, as well as greater ease of handling. The ordinary city gas pressures are too low for high temperature work with the concentrated oxygen.

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COLLEGE OF MINES

[1] Richards, Joseph W., "Metallurgical Calculations," p. 52.

USE OF SPECIAL OXIDES IN PORCELAIN BODIES[1]

By R. F. Geller and B. J. Woods

ABSTRACT

Substitution of special oxides for flint.—The oxides of thorium, titanium and zirconium and the silicate of zirconium were used. Variations in composition were based on batch weights, the percentage of oxide (or silicate) increasing from 27 to 49% with a corresponding decrease in feldspar content. A similar series using flint was also made a basis for comparison.

Effect of special oxides on drying and burning behavior, dielectric strength and resistance to spalling.—(1) *Rutile* causes high drying and burning shrinkage. The burning range is long but softening in every case results above cone 12. Resistance to spalling is above normal. (2) *Thoria* produces a body with a long burning range and great refractoriness. Drying shrinkage is normal, burning shrinkage very high, resistance to spalling very low, and the bodies warp badly. (3) *Zirconia* bodies have a normal drying shrinkage and a high burning shrinkage, no warping, long firing range, and the highest resistance to spalling. (4) *Zircon.*—The zirconium silicate bodies soften at temperatures below cone 18 and the firing range is short. Drying and burning shrinkage are similar to flint bodies but resistance to spalling is above normal.

Effect of oxides on dielectric resistance.—No effect on dielectric resistance is obtained through the use of the special oxides mentioned.

The increasing use of porcelain in many branches of the industry makes the development of special bodies, having one or more properties which adapt them to some particular purpose, of general interest. The present work consisted essentially in substituting the oxides, and in one case the silicate, of comparatively rare elements for flint with a view of increasing the electrical resistivity of the porcelain and the mechanical strength as effected by thermal changes.

For this work the oxides of thorium, titanium and zirconium were used as well as the silicate of zirconium, and a series of bodies was made introducing silica for purposes of comparison. In each case the bodies were prepared according to the following scheme outlined in table 1.

Variations in composition were based entirely on batch weights.

[1]Received April 30, 1921. Published by permission of the Director, U. S. Bureau of Standards.

TABLE 1.—GIVING COMPOSITIONS OF BODIES USED

Body No.	*a* %	*b* %	*c* %	*d* %	*e* %	*f* %	*g* %	*h* %	*i* %	*j* %	*k* %	*l* %	M %
Flint, or compound substituted for it	27	29	31	33	35	37	39	41	43	45	47	49	35
English china clay	25	25	25	25	25	25	25	25	25	25	25	25	..
Ball clay	10	10	10	10	10	10	10	10	10	10	10	10	5
Kaolin	10	10	10	10	10	10	10	10	10	10	10	10	35
Feldspar	28	26	24	22	20	18	16	14	12	10	8	6	..
Calcine No. 14	..	..	..	..	..	..	..	..	..	..	..	..	25

Body M is independent of the series and is explained later. The rutile was given seven hours grinding in a ball mill before being mixed with the other ingredients of the body. This was necessary because of its high specific gravity and its extreme hardness, which properties would not permit its being ground sufficiently fine in the ordinary course of preparation. After this preliminary grinding the rutile bodies were prepared the same as the others, *i. e.*, the ingredients were mixed, ground wet in a ball mill for three hours and screened through a 150 mesh sieve. Cups for the dielectric test were prepared both by jiggering and casting. Specimens for draw trial firing were made by forming the thoroughly hand pugged body in brass molds. The specimens were of one inch cross section by two inches long. Each piece was marked on opposite sides with a gauge having points exactly five centimeters apart for the determination of linear shrinkage in drying and burning. These pieces were carefully dried and two samples of each body were fired to cones 6, 8, 10, 12, 14 and 16, respectively, in a draw trial burn. The drying and firing shrinkage, water loss in drying, and porosity in the burned state were determined on each piece in the customary manner. Two specimens of each body were also burned to 1250°C and allowed to cool with the kiln. A spalling test was made on these pieces in the following manner: The specimens were heated to 500°C in an electric furnace and plunged into running water. This procedure was repeated until failure occurred, the number of immersions at which the pieces actually fell apart or could easily be broken with the fingers being noted.

Results

Rutile as a substitute for flint.—In the first group of bodies rutile was used as the substitute for flint. The material employed contained 95% TiO_2, the balance being made up of impurities high in iron. Table 2 presents in detail the data obtained, and from this it can be seen that drying and burning shrinkage are slightly high as compared with the flint bodies. (For results from flint series see table 6 and figure 5.) Figure 1

TABLE 2.—NUMBERS INDICATE PER CENT IN TERMS OF PLASTIC CLAY WITH THE EXCEPTION OF "POROSITY" WHICH IS IN TERMS OF THE FIRED WEIGHT

Rutile bodies

	Cone 16				Cone 14				Cone 12				
Body No.	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Maturing temp. in cones
b	3.7	X	18.5	X	4.7	X	19.0	X	5.0	13.2	19.1	0.40	6
d	5.2	X	18.8	X	5.1	X	19.2	X	5.3	14.3	19.0	0.41	6
f	3.8	X	17.1	X	5.4	X	17.5	X	5.7	15.2	17.5	0.00	6
h	6.4	X	18.3	X	6.3	X	19.0	X	5.7	16.6	18.8	0.43	8
l	5.0	X	18.9	X	5.0	X	18.7	X	5.0	15.0	18.8	0.42	8
j	4.7	X	18.7	X	4.4	X	18.9	X	4.7	14.2	19.0	0.44	10
	Cone 10				Cone 8				Cone 6				
b	5.4	14.6	19.1	0.42	4.6	13.3	19.1	0.42	4.6	14.6	19.2	0.42	6
d	5.5	14.8	18.9	0.41	5.6	14.8	18.9	0.21	5.0	14.5	19.5	0.66	6
f	4.3	12.9	16.6	0.00	5.2	14.7	18.3	0.31	4.9	12.9	17.2	0.42	6
h	5.1	16.0	18.4	0.44	4.4	14.4	17.9	0.43	5.2	15.6	18.6	3.50	8
j	5.0	15.1	18.7	0.21	5.0	13.7	18.9	0.42	4.7	13.5	18.9	3.92	8
l	4.9	15.0	19.0	0.84	4.7	13.3	19.3	1.51	4.7	13.3	19.0	9.30	10

shows graphically the burning behavior of the rutile series. Although the maturing temperature is as low as cone 6, the bodies have a long burning range to cone 12. Beyond this point they are without exception so softened and deformed that no measurement can be obtained. Below C 12 the bodies retain the dark buff color of the rutile and at higher temperatures burn from light brown to black.

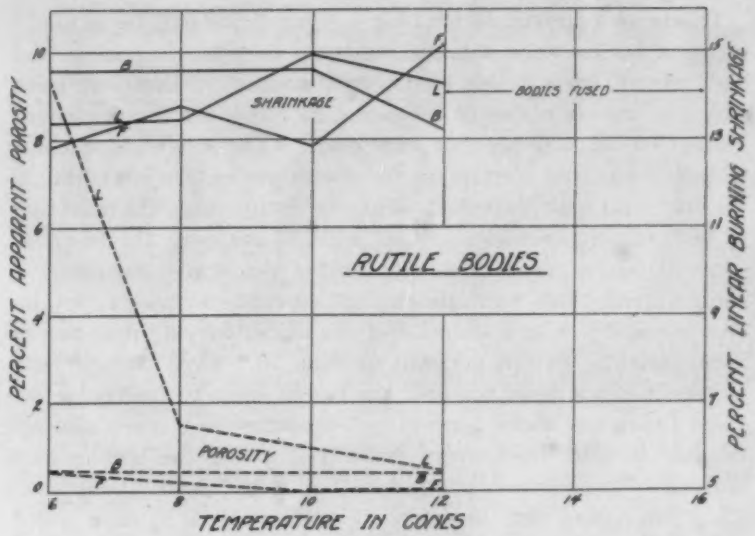
PERCENT APPARENT POROSITY
PERCENT LINEAR BURNING SHRINKAGE
SHRINKAGE
BODIES FUSED
RUTILE BODIES
POROSITY
TEMPERATURE IN CONES

FIG. 1.

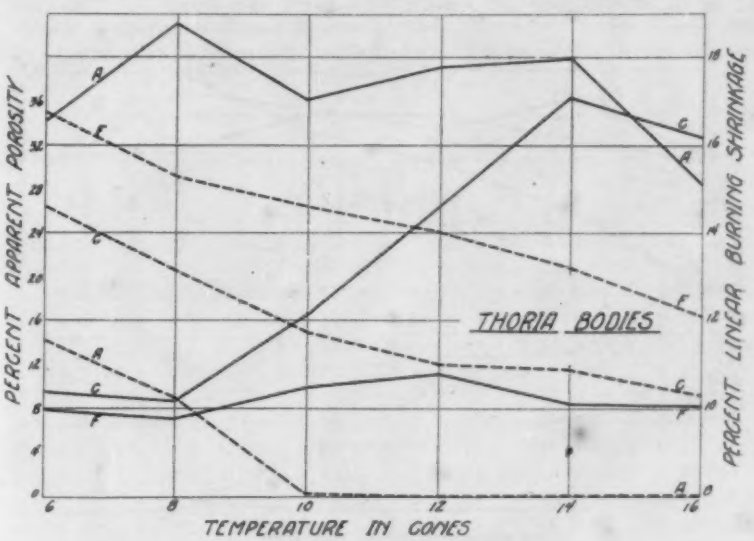
PERCENT APPARENT POROSITY
PERCENT LINEAR BURNING SHRINKAGE
THORIA BODIES
TEMPERATURE IN CONES

FIG. 2.

Thoria as a substitute for flint.—Using thoria in place of flint a group of bodies were obtained having a long burning range and high refractoriness. Due to the small amount of thoria on hand only the first six bodies of the series, in which the thoria content varies from 27 to 37 per cent, were made. The only body reaching maturity was that containing the lowest percentage of thoria, 27 per cent, and with increasing amounts of this oxide the resistance to heat rapidly increases so that with 37 per cent, the body, at cone 16 has a porosity of over twelve per cent. Shrinkage is comparatively low with the higher amounts of thoria but increases rapidly with a decrease of the oxide, varying from ten to approximately sixteen per cent at cone 16. Even though vitrification has not been reached, the bodies seem to undergo a decided expansion above cone 14. A tendency to warp is also noticeable in tests from every draw trial giving the specimens a shriveled appearance, particularly in trials fired above cone 12. The bodies vary in color from a faint pink to dead white.

Zirconia as a substitute for flint.—In the third series zirconia, containing approximately 98 per cent ZrO_2, was substituted for flint. The data obtained are shown by table 4 and figure 3. The dry-

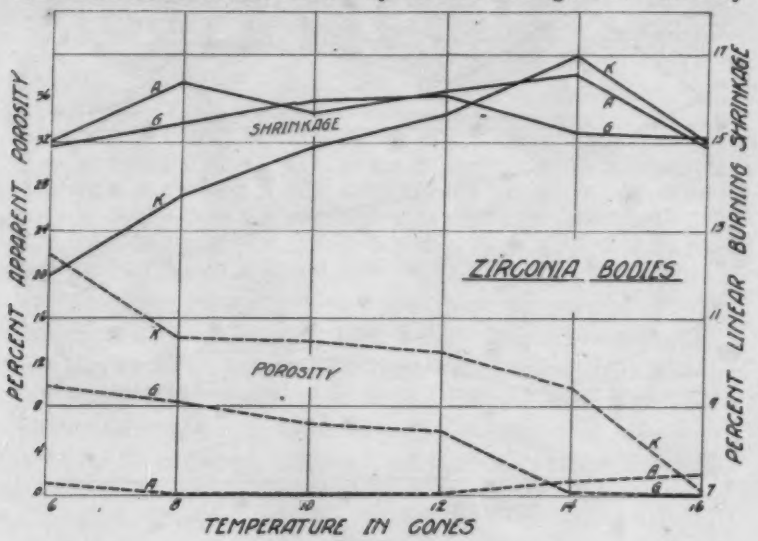

FIG. 3.

TABLE 3.—NUMBERS INDICATE PER CENT IN TERMS OF PLASTIC CLAY WITH THE EXCEPTION OF "POROSITY" WHICH IS IN TERMS OF THE FIRED WEIGHT

Thoria bodies

Body No.	Cone 16				Cone 14				Cone 12				Maturing temp. in cones
	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	
a	5.8	15.1	22.3	0.07	6.1	18.0	22.1	0.24	5.6	17.8	22.5	1.92	14
b	6.6	16.8	22.5	5.4	6.6	19.0	22.9	9.4	6.6	19.5	22.5	10.7	16+
c	5.9	16.2	23.4	9.12	6.0	17.1	23.5	11.6	4.7	11.3	23.4	12.6	16+
d	X	12.0	24.3	10.1	X	9.9	23.2	12.0	X	10.0	23.2	15.8	16+
e	6.0	12.2	25.2	12.6	6.2	12.1	25.8	16.0	6.4	12.5	25.2	17.3	16+
f	4.7	10.0	25.8	16.3	4.8	9.8	25.5	20.9	5.0	10.5	25.6	24.2	16+
	Cone 10				Cone 8				Cone 6				
a	6.7	17.0	22.5	2.25	6.0	18.8	22.5	9.15	5.1	16.7	22.5	14.2	14
b	6.1	15.7	22.9	13.3	6.7	16.3	3.0	15.9	5.7	13.0	22.5	23.1	16+
c	4.6	12.1	23.4	15.1	4.6	10.2	23.5	20.7	4.8	10.4	23.1	26.4	16+
d	X	11.9	23.6	20.4	X	X	23.9	X	X	X	24.5	X	16+
e	5.7	10.9	26.2	23.7	5.7	12.6	25.7	25.2	5.4	10.4	25.8	27.5	16+
f	5.3	10.8	25.8	26.3	5.5	10.2	25.9	29.2	5.3	10.1	26.4	33.3	16+

TABLE 4.—NUMBERS INDICATE PER CENT IN TERMS OF PLASTIC CLAY WITH THE EXCEPTION OF "POROSITY" WHICH IS IN TERMS OF THE FIRED WEIGHT

Zirconia bodies

Body No.	Cone 16				Cone 14				Cone 12				Maturing temp. in cones
	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	
a	5.1	15.4	17.7	0.98	6.6	16.8	17.8	0.64	5.4	16.1	17.8	0.04	6
b	5.0	15.0	18.3	0.00	2.7	15.2	17.8	X	2.8	16.6	17.5	0.00	8
c	4.0	14.2	18.7	X	3.8	14.3	19.3	0.04	4.4	16.1	18.7	0.21	10
d	4.0	14.2	18.1	0.10	3.6	15.3	18.1	0.10	3.4	14.6	18.0	0.25	10
e	4.2	14.4	19.2	0.20	4.5	15.3	19.5	0.86	4.0	15.5	19.7	0.13	10
f	3.0	13.2	18.6	0.12	3.7	13.7	19.2	0.28	4.6	15.9	19.2	1.34	14
g	5.4	15.1	19.3	0.06	5.0	15.2	19.0	0.28	5.8	16.0	20.2	5.79	14
h	3.4	13.9	19.2	0.30	3.3	14.2	19.3	0.31	4.1	15.5	19.4	9.1	14
i	4.9	14.1	18.6	0.16	3.4	14.1	18.9	0.84	4.5	15.9	19.6	9.24	14
j	6.2	15.4	20.8	2.53	6.5	15.1	21.0	4.86	5.8	15.6	20.7	12.70	16+
k	4.6	14.9	20.1	0.19	4.2	17.0	19.5	4.38	4.5	15.7	20.0	19.50	16
l	3.8	13.2	18.2	2.09	3.8	13.1	19.2	9.82	4.1	14.3	18.9	14.30	16+

TABLE 4 (*Continued*)

	Cone 10				Cone 8				Cone 6				
a	5.0	15.7	17.9	0.00	6.0	16.2	18.4	0.11	4.3	15.0	17.8	0.89	6
b	2.8	15.3	17.4	0.00	2.7	15.9	17.7	0.36	3.6	15.4	17.4	X	8
c	4.4	16.1	19.5	0.13	4.4	17.0	19.9	0.19	4.3	16.2	18.9	3.10	10
d	4.2	15.9	17.9	0.17	3.6	15.4	17.6	0.32	3.3	14.2	17.6	6.16	10
e	4.5	16.0	19.4	0.00	4.6	16.8	19.2	1.46	4.2	15.2	18.8	8.22	10
f	4.3	16.2	18.2	1.75	4.5	16.1	18.5	4.05	4.0	14.5	18.3	13.10	14
g	5.8	16.0	20.0	6.51	4.8	14.5	19.2	8.62	6.1	15.0	19.3	8.97	14
h	4.0	16.5	19.7	7.70	4.1	13.4	19.5	9.13	4.4	14.6	19.8	9.00	14
i	4.1	16.2	19.5	9.35	4.4	15.6	19.3	10.50	4.5	15.4	19.2	12.10	14
j	5.6	15.6	20.8	11.00	6.2	16.3	20.8	12.60	5.4	15.6	20.8	16.90	16+
k	4.7	14.9	19.7	14.12	4.4	13.8	19.8	14.30	4.4	12.0	19.6	21.80	16
l	4.7	14.3	18.9	15.50	5.0	13.6	18.9	14.70	4.3	13.1	18.8	17.70	16+

ing shrinkage and water of plasticity are about the same as for the flint bodies, while the burning shrinkage is the highest obtained next to the thoria bodies. Unlike the thoria series, however, these specimens show no warping or blistering at any stage. The color of the burned body is uniformly good and after vitrification shows a very tough fracture. As the graphs in figure 3 show, the shrinkage, although high, is very uniform considering the range of temperature and the wide variation in the per cent of the refractory constituent. The porosity curves also are comparatively uniform and lie quite closely together. Although the bodies low in zirconia are vitrified at cone temperatures 6 to 10, there is no harmful overburning evident at the highest heat reached in this work.

Since the zirconia produced a body of good burning properties and excellent structure, it was decided to duplicate the work with zircon, which is the naturally occurring mineral $ZrSiO_4$. This material was approximately 95% pure, washed iron free, and considerably cheaper than zirconia. Although the same batch weights of the silicate of zirconium were used as for the oxide, the acid-base ratios in the empirical formula were not changed very decidedly since both the silica and zirconia, which theoretically constitute the silicate, belong to the RO_2 group. This is shown by the following formulas:

Body A

Using ZrO_2	Using $ZrSiO_4$
1.00 K_2O : 4.5 Al_2O_3 : 13.0 SiO_2 : 4.2 ZrO_2	1.00 K_2O : 4.5 Al_2O_3 : 15.7 SiO_2 : 2.5 ZrO_2

Body B

1.00 K_2O : 10.75 Al_2O_3: 25.4 SiO_2 : 22.4 ZrO_2	1.00 K_2O : 10.75 Al_2O_3: 38.2 SiO_2 : 12.8 ZrO_2

TABLE 5.—NUMBERS INDICATE PER CENT IN TERMS OF PLASTIC CLAY WITH THE EXCEPTION OF "POROSITY" WHICH IS IN TERMS OF THE FIRED WEIGHT

Zirconium silicate bodies

Body No.	Cone 16				Cone 14				Cone 12				Maturing temp. in cones
	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	
	%	%	%	%	%	%	%	%	%	%	%	%	
a	5.4	12.3	18.8	8.53	5.1	13.2	19.2	2.33	5.0	13.8	18.8	0.66	10
b	3.9	10.4	18.0	7.14	4.2	11.9	18.0	0.83	4.1	13.1	17.7	1.46	10
c	2.9	10.2	16.0	8.20	3.3	11.0	16.1	1.03	3.3	11.4	16.0	0.61	12
d	3.9	12.3	17.1	6.36	4.4	13.6	17.6	0.21	4.4	X	17.0	0.09	12
e	4.5	X	17.2	8.6	4.1	14.4	17.9	0.42	4.0	12.7	17.7	0.41	12
f	5.2	X	17.7	4.79	4.5	12.8	17.8	0.42	4.8	12.8	17.9	5.27	14
g	4.0	X	18.9	7.30	4.2	13.7	19.0	0.44	3.9	13.2	18.4	1.07	14
h	5.0	X	18.7	6.86	5.0	15.2	18.0	0.43	5.0	13.8	18.9	2.42	14
i	5.2	X	17.0	3.02	5.2	14.2	17.2	0.20	5.3	13.5	17.2	12.10	14
j	5.2	12.4	16.6	6.50	4.6	12.3	17.2	0.83	5.3	13.0	17.1	7.80	14
k	5.0	X	17.3	0.62	5.5	13.8	17.3	3.28	5.5	13.3	17.3	8.75	16
l	5.0	X	16.8	3.98	5.1	X	16.9	1.41	5.5	12.5	16.8	13.90	14
	Cone 10				Cone 8				Cone 6				
	%	%	%	%	%	%	%	%	%	%	%	%	
a	5.0	13.0	18.7	0.66	4.7	11.7	18.5	6.59	5.3	11.9	18.9	15.90	10
b	3.9	11.9	17.8	0.8	4.3	11.2	17.7	8.04	4.0	9.5	17.8	19.40	10
c	3.0	11.0	16.0	3.80	3.0	11.2	16.0	7.21	3.4	9.8	16.5	19.40	12
d	3.9	12.3	17.1	5.40	3.9	11.9	17.2	10.00	4.7	11.9	17.6	17.00	12
e	4.2	12.5	17.7	6.20	4.0	10.5	17.7	13.20	4.2	9.7	17.3	18.90	12
f	4.6	11.6	18.1	5.43	4.2	10.6	18.1	15.00	4.0	9.5	18.0	22.40	14
g	4.2	12.8	19.0	9.10	4.5	12.1	19.0	12.10	4.4	12.3	18.9	21.30	14
h	5.1	12.2	18.9	9.33	5.3	11.8	19.0	17.20	5.2	10.9	19.0	24.90	14
i	5.3	12.7	17.4	12.30	4.9	11.1	17.2	16.70	5.4	10.0	17.3	24.90	14
j	4.9	12.5	17.1	13.20	5.5	11.8	17.2	15.40	5.1	10.2	16.9	23.20	14
k	5.5	12.5	17.3	4.28	5.5	11.8	17.4	19.20	5.5	10.0	17.1	25.30	16
l	5.0	11.1	16.8	13.90	5.1	10.4	16.7	21.00	5.4	9.6	16.9	25.10	14

The color of the draw trials vary from a faint gray at cone 6 to a yellow brown at cone 16. At the higher temperatures the specimens tend to warp and blister. This tendency to distort in burning increases with increasing amounts of $ZrSiO_4$ although the refactoriness is also increased. As the graph indicates, linear shrinkage can not be obtained on the bodies high in silicate due to this distortion, while all the bodies have softened considerably at cone 16 with the exception of the two highest in zircon. The fact that these bodies soften at temperatures lower than those of the zirconia bodies is no doubt due to the formation of a eutectic between zircon and cristobalite form of silica. This eutectic has been given as probably lying close to the molecular proportion of 10 ZrO_2 and 90 SiO_2. Its melting temperature has not as yet been determined. The firing range of the zircon bodies is comparatively short and shows serious overburning at cone 16.

Considering the general firing behavior of these bodies then, as compared with the flint series, we find that the rutile series have a rather long range but soften rapidly above cone 12. Thoria on the contrary produces an extremely refractory body which also has a long firing range but a soft structure. Zircon tends to form a eutectic which causes the bodies to have a narrow maturing range and also causes warping and blistering. The zirconia bodies do not overburn and the firing range compares very favorably with the flint series. The structure is hard and the fracture appears very tough. From the data given in table 7, we see that a zirconia content as low as 35 per cent produces a body of maximum toughness which matures at cone 10–12. The resistance of the bodies to sudden temperature changes is on the whole very satisfactory, being more than four times as great as that of the flint body, according to the results of the spalling tests. Although the various oxides affect the mechanical strength of porcelain considerably, it is evident that the electrical resistivity is practically the same for all, including the flint body (see table No. 7). The resistivity is shown by the "TE" value. This figure indicates the temperature in degrees Centigrade at which a cubic centimeter of the material still shows a resistance of one megohm.[1] Due to lack of material cups were not made of the

[1] THIS JOURNAL, 1, 600 (1918).

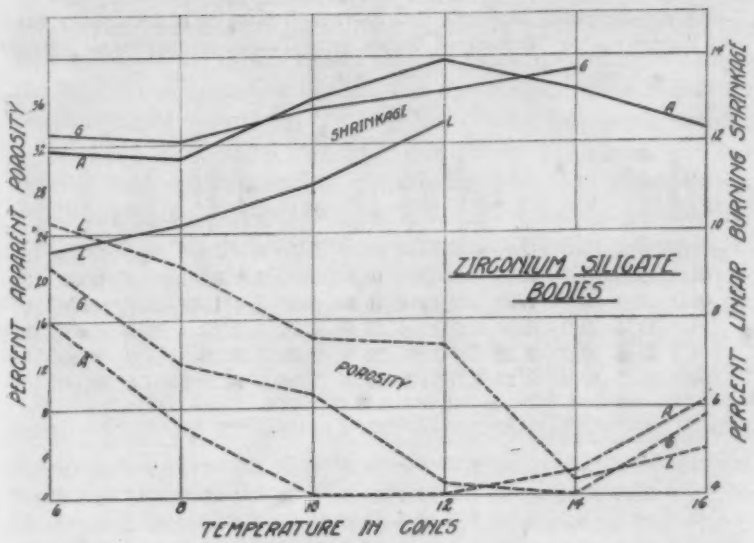
PERCENT APPARENT POROSITY
PERCENT LINEAR BURNING SHRINKAGE
SHRINKAGE
POROSITY
ZIRCONIUM SILICATE BODIES
TEMPERATURE IN CONES

FIG. 4.

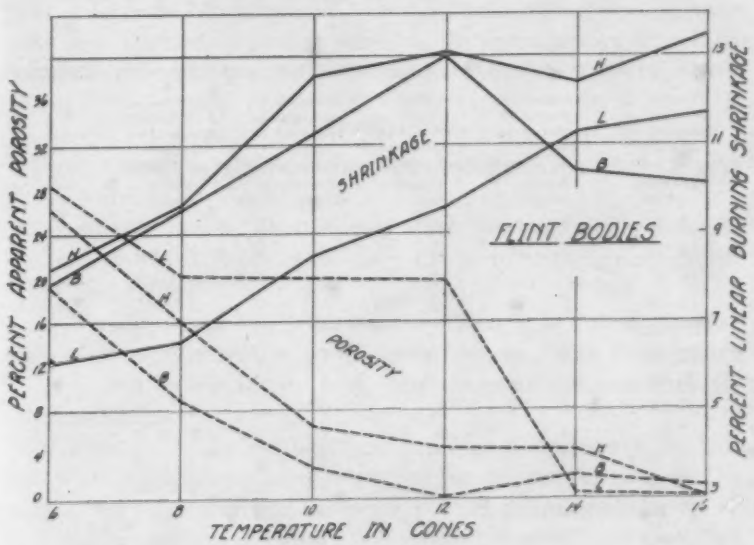
PERCENT APPARENT POROSITY
PERCENT LINEAR BURNING SHRINKAGE
SHRINKAGE
POROSITY
FLINT BODIES
TEMPERATURE IN CONES

FIG. 5.

TABLE 6.—NUMBERS INDICATE PER CENT IN TERMS OF PLASTIC CLAY WITH THE EXCEPTION OF "POROSITY" WHICH IS IN TERMS OF THE FIRED WEIGHT

	Cone 16				Cone 14				Cone 12				
Body No.	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Maturing temp. in cones
b	4.0	10.1	15.9	1.04	4.0	10.4	18.4	2.50	4.0	13.0	18.5	0.41	12
d	4.4	12.0	19.7	0.36	4.2	12.1	18.8	4.30	4.6	13.3	18.6	0.70	12
f	5.1	12.1	19.2	0.36	4.9	12.8	19.3	2.60	5.3	13.3	19.6	1.20	16
h	6.0	13.4	20.0	0.20	5.3	12.4	19.8	4.77	5.7	13.1	19.7	4.76	16
j	4.8	13.7	20.1	2.40	4.3	12.7	20.0	1.22	3.8	10.8	19.8	8.30	16+
l	4.0	11.7	19.4	3.15	4.5	11.3	19.8	2.15	3.7	9.6	19.8	20.00	16+
	Cone 10				Cone 8				Cone 6				
b	3.4	11.2	18.3	3.02	3.5	9.6	18.3	9.05	3.7	7.7	18.1	19.40	12
d	4.4	13.3	19.4	4.40	4.7	12.1	19.2	6.60	4.2	12.0	19.1	19.70	12
f	5.7	12.9	19.5	6.70	5.4	10.0	19.3	14.30	5.4	8.3	19.2	26.00	16
h	5.6	12.6	19.8	6.49	4.7	9.6	20.0	16.10	4.3	8.2	20.1	26.60	16
j	4.7	10.6	20.0	6.56	5.4	11.8	20.5	16.50	4.4	7.9	20.1	26.50	16+
l	5.0	8.5	19.5	21.30	4.9	6.6	19.7	23.50	4.2	6.1	19.6	28.40	16+

TABLE 7.—SHOWING RESULTS OF SPALLING TEST, AND ELECTRICAL RESISTIVITY

Body No.	Number of immersions required to cause—cracks failure		Number of immersions required to cause—cracks failure		Number of immersions required to cause—cracks failure		Number of immersions required to cause—cracks failure		Number of immersions required to cause—cracks failure		Body M
	Zirconia series		Rutile series		Thoria series		Zirconium silicate series		Flint series		
a	16	32	..	..	2	14	6	10	4	5	
b	16	22	7	10	2	21	8	9	3	5	
c	16	32	..	..	2	19	6	7	3	6	Maturing
d	16	48	7	8	2	22	8	9	3	5	Temp.C14
e	20	50+	..	..	2	15	9	10	3	6	"Te" value
f	20	50+	6	8	2	17	7	9	3	4	= 610
g	20	50+	..	..	..	..	8	9	4	6	
h	20	50+	6	7	..	..	9	10	4	5	
i	17	31	..	..	..	..	8	9	3	7	
j	17	50+	7	9	..	..	8	9	3	5	
k	17	29	..	..	..	..	8	12	2	4	
l	17	50+	9	12	..	..	9	10	2	4	
"Te" value	Body f 390		Body f 370		Body f ..		Body f 390		Body f 390		

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[1] *Ibid.*, **2**, 564 (1919).

(*d*) The vitrification of these bodies through the agency of the feldspar is not influenced to any great extent by the presence of the refractory oxides. They merely behave as inert bodies and the compositions containing them vitrify at higher or lower temperatures according to the feldspar content. There appears to be in general no increase in the refractoriness of the body as compared with a body containing an equal amount of quartz, although in the case of thoria there seems to be some hardening of the vitrifying matrix.

(*e*) The several oxides used in this work do not affect the electrical resistivity of the porcelain in which they are incorporated.

(*f*) A desirable porcelain for electrical purposes can be produced by substituting zirconia for flint (since zirconia is practically unaffected by thermal changes), and using a prepared flux as described to nullify the effect of feldspar on the resistivity.

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TABLE 6.—NUMBERS INDICATE PER CENT IN TERMS OF PLASTIC CLAY WITH THE EXCEPTION OF "POROSITY" WHICH IS IN TERMS OF THE FIRED WEIGHT

Body No.	Cone 16				Cone 14				Cone 12				Maturing temp. in cones
	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	Drying shrinkage	Burning shrinkage	Water of plasticity	Porosity	
b	4.0	10.1	15.9	1.04	4.0	10.4	18.4	2.50	4.0	13.0	18.5	0.41	12
d	4.4	12.0	19.7	0.36	4.2	12.1	18.8	4.30	4.6	13.3	18.6	0.70	12
f	5.1	12.1	19.2	0.36	4.9	12.8	19.3	2.60	5.3	13.3	19.6	1.20	16
h	6.0	13.4	20.0	0.20	5.3	12.4	19.8	4.77	5.7	13.1	19.7	4.76	16
j	4.8	13.7	20.1	2.40	4.3	12.7	20.0	1.22	3.8	10.8	19.8	8.30	16+
l	4.0	11.7	19.4	3.15	4.5	11.3	19.8	2.15	3.7	9.6	19.8	20.00	16+
	Cone 10				Cone 8				Cone 6				
b	3.4	11.2	18.3	3.02	3.5	9.6	18.3	9.05	3.7	7.7	18.1	19.40	12
d	4.4	13.3	19.4	4.40	4.7	12.1	19.2	6.60	4.2	12.0	19.1	19.70	12
f	5.7	12.9	19.5	6.70	5.4	10.0	19.3	14.30	5.4	8.3	19.2	26.00	16
h	5.6	12.6	19.8	6.49	4.7	9.6	20.0	16.10	4.3	8.2	20.1	26.60	16
j	4.7	10.6	20.0	6.56	5.4	11.8	20.5	16.50	4.4	7.9	20.1	26.50	16+
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General and Miscellaneous

1. Successful operation of a waste heat dryer. J. H. KRUSON. *Brick Clay Record*, **59**, 266–268 (1921).—Clays may be divided into three groups as regards their drying behavior. A-Clays that will not dry safely in a circulating atmosphere; B-Clays requiring a low temp. or nearly saturated condition on entering a moving atmosphere; and C-Clays requiring a heating chamber in a stagnant non-drying atmosphere before they enter a slow drying atmosphere. For the month of Jan. 5,983 cu. ft. of air held one lb. of H_2O whereas in July only 1,127 cu. ft. were required to hold the same amt. As weather conditions change some adjustment must be made in temp. or the vol. of incoming air in order that an even amt. of H_2O be evaporated.

H. G. SHURECHT

2. Shrinkage on drying kaolins and clays. A. BIGOT. *Compt. rend.*, **172**, 755–8 (1921).—Small test specimens were made from a number of kaolins and clays of French origin, usually molded by hand in plaster molds from a soft paste; a few specimens were formed in steel molds under pressure. The specimens were dried in air and finally at 110°, detn. of length and wt. being made at intervals. The water given off while the specimen was shrinking was called colloidal water; that given off after shrinkage had ceased, interposed (pore) water. A number to express the *plasticity* of the clay was obtained by dividing the wt. of colloidal water by the wt. of total water and multiplying by the shrinkage. The chemical analyses, colloidal water, total water, contraction, and plasticity numbers of the clays examd. are given in a table.

J. S. LAIRD (*C. A.*)

3. Georgia (kaolin) clays and their development. T. P. MAYNARD. *Manufacturers' Rec.*, **78**, No. 10, 135–9 (1920).—The white clay deposits of Georgia are very extensive, occurring largely in the coastal plain. The kaolin mined has been used largely in the manuf. of paper, but also in rubber goods, paints, pottery. The clays are sedimentary and plastic, but vary widely in their properties and in compn. from typical kaolin to bauxite. J. S. LAIRD (*C. A.*)

4. Ruggles-Coles dryer. H. JORDAN. *Feuerungstechnick*, **9**, 31–3(1920).—The construction and operation of various forms of Ruggles-Coles driers are discussed with photographs and drawings of the various classes. Also in *Chem. App.* **8**, 32–4 (1921). H. C. PARRISH (*C. A.*)

PATENTS

5. Shaping device for articles made of ceramic bonded material. PEHR JOHANSON AND ERNEST A. FRANCKE. U. S. 1,376,773, May 3, 1921. A device for shaping articles of bonded material, having a projecting center to form a center hole in the article, a blade rotatably mounted on the device, and means for the blade while rotating to move bodily toward the work to a predetermined extent and thereafter to freely rotate without substantial movement toward the work.

6. Drying-kiln. SIDNEY E. CORNISH. U. S. 1,376,319, April 26, 1921. A kiln, with fans at one side, and flues connecting the fans with the other side of the kiln, whereby a continuous circuitous circulation of air is provided transversely through the kiln.

7. Method of making clay and graphite crucibles. JEAN HUBERT LOUIS DEBATS. U. S. 1,374,909, April 19, 1921. The method of making crucibles or pots containing clay, which consists in mixing non-ferrous metal with the material from which the crucible or pot is formed, and forming the crucible or pot therefrom, whereby in the use of the crucible or pot the metal forms a metallic silicate coating on the surface thereof. C. M. SOEGER, JR.

BOOK

8. Taschenbuch für keramiker 1921. Berlin: Verlag Keramische Rundschau G. m. b. H. M8. For review see *Tonind.-Ztg.* **45,** 37(1921). (*C. A.*)

Apparatus and Instruments

9. Instrument determines carbon dioxide and detects carbon monoxide ANON. *Elec. Rev.* (Chicago), **78,** 634–6(1921).—A discussion of combustion and the efficiency from analyses. Curves show the relation of flue-gas heat loss to the % CO_2, and the relation when combustibles appear at 14% CO_2. An app. is described that analyzes and records the CO_2 present at all times in flue gases, simultaneously detecting and recording the presence and approximate proportion of combustible gases. Actual percentages are rarely less than $^2/_3$ or more than equal to the amts. recorded. The instrument is driven by water pressure. Gas samples are passed through the filtering system, and then forced through the app. by means of a Hg piston. The gas is passed alternately through two routes, one directly through a KOH tank and the other first through an elec. furnace wherein combustible gases are oxidized to CO_2 and H_2O, and then through the KOH tank. The difference in readings is proportional to the amt. of combustible gas present. In the elec. furnace, the O is taken from the air invariably present in flue gases, or from CuO provided in the furnace. Communicating tubes are used to diminish the lag between the time the gas leaves the flue and when the analysis is recorded on the chart. The app. is dirtproof and requires little attention.

W. H. BOYNTON (*C. A.*)

10. A comparison of monochromatic screens for optical pyrometry. W. E. FORSYTHE. Nela Research Lab., Cleveland, O. *J. Optical Soc. Am.*, **5,** 85–95(1921).—Screens of Jena red glass, a Corning Co. green glass, and blue uviol glass were compared to find their relative efficiency. Reasons are given for preferring red glass. (*C. A.*)

11. Mixing. OTTO STIER. Heidelberg. *Chem. Ztg.*, **44,** 902–5(1920).—A survey of the recognized com. methods for mixing liquids with liquids, liquids with solids, and solids with solids. This includes descriptions of shaking, stirring, and air-current methods for liquids and sludges; kneading and churning for plastic masses; and shaking, stirring and rotating for solids. Numerous diagrams and explanations are given to show approved app. and equipment. C. C. DAVIS (*C. A.*)

Chemistry, Physics and Geology of Raw Materials

12. Prism hardness; new test of hardness. B. P. HAIGH. *J. Inst. Mech. Eng.*, **7,** 891–913(1920).—The significance of the term hardness is discussed

and the principles of the new method explained. The test pieces consist of square prisms placed cross-wise with their edges in contact and subjected to a measured load. For small indentations the form of indentation was found to be independent of the load and reproducible values were obtained by dividing the loads by the squares of any characteristic linear dimension of the indentation. The values found were independent of the angle of the prism. The apparatus is described together with results obtained with different metals. ED.

13. Colloid chemistry of clays and clay products. A. B. SEARLE. *3rd. rep. on colloid chem. and its gen. and ind. appl.* Brit. Depart. Sci. Ind. Res. 113–153 (1920).—A review of the present state of our knowledge. ED.

14. Viscosity and flocculation of coarse suspensions. HANS EGNÉR. *Meid. K. Vetenskapsakad. Nobelinst.*, **4**, No. 4, 27 pp.—It is shown by viscosity measurements that no general formula for calcg. the viscosity of a suspension from its volume concn. is generally satisfactory. The properties of suspensions are shown to resemble closely those of suspension colloids. They are generally negatively charged and show characteristic electric endosmosis, cataphoresis, etc. Electrolytes have a great effect upon the state of these coarse suspensions. Cations flocculate and increase the viscosity and sedimentation height. Anions act in the opposite direction. With the exception of OH ions, which act irregularly, the magnitude of their flocculation power generally changes according to Hardy's law. (Cf. *C. A.* **14**, 1916.)
A. E. STEARN (*C. A.*)

15. The colloidal character of clays and their practical application. ALBERT BENCKE. *Sprechsaal*, **53**, 490–491 (1920).—By means of the ultra-microscope the colloidal matter in clays may be identified. When a salt solution as NH_4Cl, $BaCl_2$, $Al_2(SO_4)_3$ and $CuSO_4$ is allowed to stand in contact with clay a definite amt. of the basic ions are adsorbed by the clay. For ex. 1 gr. of kaolin adsorbs 0.0038 to 0.0169 grs. of CuO from a 50 cc. sol. containing 2 grs. of $CuSO_4$. 0.077 grs. NH_4 from NH_4Cl, 0.373 grs. Ba from $BaCl_2$ and 0.075 grs. Al from $Al_2(SO_4)_3$ are adsorbed from a 0.1 n. sols. in 3 das. Certain organic compounds, as tannin, have a deflocculating effect on clays. Tannin also acts as a protective colloid and to a certain extent prevents deflocculation by alkalies. The addition of a small amt. of Al_2Cl_6 or tannic acid to kaolins increases the plasticity decidedly while alkalies have the opposite effect. Upon calcining clays to 500°–900° C, irreversible colloids are formed. Upon driving off the chem. H_2O the clay combines with SO_2 and SO_3, thus acting as a catalyser in the oxidation of SO_2 to SO_3. This property of clay will make it valuable as a catalyser in many chem. reactions. During the dehydration of clays the reaction is endothermic but upon heating above 900°C it is exothermic. At this point the clay is probably decomposed into $Al_2O_3.SiO_2$ and SiO_2. Upon further heating the clay gradually becomes a liquid and the surface tension plays an important rôle. H. G. SCHURECHT

16. Solution and growth forms of quartz from sodium tetraborate solutions heated under pressure. GABRIEL LINCIO. Turin. *Beitr. Kryst. Miner-*

alogie, **1**, 87–101 (1916).—The Spezia app. for heating minerals in contact with solns. under pressure was used. Spheres of quartz were placed in this, one above and one below a vessel containing quartz fragments, and the whole was surrounded by a 6% aq. soln. of $Na_2B_4O_7$. In the growth chamber the temp. reached about 170°, in the soln. chamber 320°. Chem. reaction occurs between the quartz and the borax, apparently with the formation of a Na borosilicate. After 25 days the app. was opened and the growth and soln. figs. on the respective spheres were studied. The trigonal character of the mineral is strikingly brought out, and conclusions can be drawn as to the *mechanism of soln. and deposition processes* from the features exhibited.

E. T. W. (*C. A.*)

17. The silicate chemist in industry. C. LOESER. *Chem. Ztg.*, **44**, 955–6 (1920).—The silicate chemist has to develop a field between those of the pure chemist and the mechanical engineer. His technical training should be designed to give a thorough knowledge of the fundamentals of chemistry with particular emphasis on inorg. chemistry. In addition he requires instruction in structural and mechanical engineering. J. S. LAIRD (*C. A.*)

18. Cornish stones of England, ANON. *Tonind.-Ztg.*, **45**, 442 (1921).—Cornish stone is a natural mixt. of feldspar and quartz together with kaolin fluorspar, muscovite and topaz. It is often found in the same bed with China clay. It contains albite or albite-oligoclase as well as orthoclase. There are many different varieties of Cornish stone varying from hard purple, to mild purple, dry white and buff stone. The softer varieties show a higher degree of kaolinization. Typical analyses are as follows:

	Hard purple	Buff (Cornish)	Dry white
SiO_2	72.28	73.18	73.96
Al_2O_3	14.90	16.13	15.90
Fe_2O_3	0.50	0.52	1.40
MnO	0.01	0.02	—
CaO	1.66	0.61	1.89
MgO	0.15	0.14	0.32
K_2O	5.25	4.41	4.34
Na_2O	3.01	2.18	0.45
H_2O	0.81	2.01	1.11
P_2O_5	0.53	0.45	—
F	0.88	0.23	—
Cl	0.02	—	—
TiO_2	0.05	0.06	—
Li_2O	0.02	0.02	—

	Kaolin	Feldspar	Quartz
Purple stone	6.7	77.2	16.1
Buff stone	14.6	55.5	30.9

H. G. SCHURECHT

Geology

19. Automatic method for mechanical soil [and clay] analysis and ways of recording it. SVEN ODÉN. *Bull. Geol. Inst. Univ. Upsala*, **16**, 15–64 (1919); cf. *C. A.* **13**, 1198 (1919).—Exact mechanical soil analysis is difficult because of the dependence on temp. and uniformity of sample. It is measured through the behavior of particles of soil falling in a liquid. Theoretically the velocity of particles may be expressed as $V = Cr^2$ (Stokes law), where C is a const. equal to $(^2/_9)g[(\sigma-\sigma_1)/\mu]$, where g is the const. of gravitation, σ the sp. gr. of the particles and σ_1 that of the liquid and μ the size of particle. This equation is based upon the supposition that the size of particles does not exceed a certain critical radius (85μ for quartz). As particles usually have different forms it is necessary to introduce a radius of equivalence for particles. The medium radius of equivalence for a certain amount of soil should then be equal to the medium size of particles in suspension. If medium sp. gr. of soil be placed at 2.7 and μ be given as 0.0114 at 15° in abs. measure, the const. C in an aq. suspension should equal $5.546.10^{-3}$. This const. will vary with μ which again varies very much with temp. If a substance varying in size is suspended in a liquid: (1) Velocity of accumulation is proportional to the total amt. of the substance and reciprocally proportional to the height of the liquid, but independent of time. (2) If v_i is the velocity of particles of size i then an equal amt. each of particles of smaller size will sink down in the time interval O to h/v_i. For carrying out expts. O. used a glass cylinder 35 cm. high and 138 mm. inside diam. filled with water. Inside of this and near the bottom a gold-plated silver plate is hung up by strings in the water. The substance to be analyzed is let in on top of the cylinder and a certain amt. is collected on to the plate, which again is connected with an automatic balance. When this balance is upset an elec. current closes releasing small steel shot, which again equal the wt. of collecting particles on the scale. The steel shots have to be uniform and are chosen in 4 sizes weighing, resp., 0.4366 g., 0.1276 g., 0.0544 g., 0.0133 g. Velocity of accumulation is thus closely detd. and recorded on a recording app. attached to the balance. After expts. are made and recorded the number of particles is counted with the ultra-microscope after the method of Zsigmondy-Siedentopf. A falling curve may be shown in a diagram with the amts. of particles g (r) as ordinates and the radii of equivalence r as abscissas. Graphically this may be shown by the integration of a function $F(r)$ between r_1 and r_2:

$$g(r_1) - g(r_2) = \int_{r_2} (dq/dr)dr = \int_{r_1}^{r} F(r)dr.$$

$F(r)$ represents here the curve of distribution of the particles and this may be calcd. from the above formula. Sometimes particles will coagulate, the falling curve then differing slightly from the ordinary one. The curve of distribution is calcd. and shown in a diagram, where ordinates and abscissas are represented, resp., by the logarithms of dP/dt and of t (P = weight of par-

ticles). N is number of particles and being a function of r_1 $N(r)$ is called function of frequency. Tables and diagrams show results obtained with Danish Rhaet Ler and mica-clay from Venid. Three photographs are given of cylinder, automatic balance and recording app., resp. **Preliminary treatment of soil in mechanical analysis.** *Ibid.*, 125–34.—In different soils individual particles are often combined into aggregates differing from the primary particles. In preliminary treatments, such aggregates are broken up, all particles being reduced to primary ones. Normal method for treatment: The material is brushed with a stiff brush when in distd. water; then the larger particles are removed in a centrifuge and the material is brushed again. Enough NH_3 is added to give a 0.01 N soln. and the whole is mixed in a machine for 24 hrs. NH_3 breaks up aggregates especially well for soils containing Ca salts, NaCl, KCl and $MgCl_2$. Boiling breaks up aggregates also but produces coagulation afterwards; it is therefore not advizable to boil.

G. N. KIRSEBOM (*C. A.*)

20. Clay of Ancylus. SVEN ODÉN AND A. REUTERSKIOLD. *Bull. Geol. Inst. Univ. Upsala*, **16**, 135–58(1919).—Expts. were carried out on this clay according to methods given by Odén (preceding abstract). The clay of Ancylus was geologically detd. as Post-Glacial sweet-water sediment formed in the intermediary period, when the Baltic Sea was shut out from the Atlantic, forming the Ancylus lake, so-called after the mollusk *Ancylus fluviatilis* found in the sediment. Mechanical analysis detd. the size of particles to be between 0.17 and 7.0μ. Chemically the particles differ in compn. according to size, the larger ones being richer in silica. Samples were dissolved in strong HCl to find the action on the particles. Results are given of different size fractions before and after treatment with acid, av. size of articles and their number being detd. Fractions taken were $<0.23\mu$, 0.23–0.60μ, 0.60–1.05μ and 1.05–5.13μ. In the original sample 33.5% was undissolved. Action of acid was strongest on the fraction around 0.4μ. Av. size of particles increased in smaller fractions but decreased in larger ones. Tables show results of mechanical tests and a graphic table indicates the influence of HCl on chem. compn.

G. N. KIRSEBOM (*C. A.*)

Refractories and Furnaces

21. Unfired refractory brick. P. SCHNEIDER. *Tonind.-Ztg.*, **45**, 452–454(1921).—The properties of silica brick made in a manner similar to sand-lime brick were studied. The brick were built into the furnaces in the unfired state. The results are summarized in the following tables.

	Compression strength kg. /cm.²					Volume shrinkage	
No.	Raw	Hardened	650°C	Cone 10	Cone 14	Cone 10	Cone 14
1	very weak	149	38	115	280	+0.8	± 0.
2	10	40	36.3	95	360	+1.1	+ 1.9
3	8	51.5	36	92	350	+1.3	+ 2.24
4	10	180	68	132	210	+0.5	+ 1.76

TABLE (*Continued*)

No.	Raw	Hardened	650°C.	Cone 10	Cone 14	Cone 10	Cone 14
5	12	165	74	140	240	+0.5	+ 1.80
6	15	78	53.5	150	170	+0.8	+ 1.0
7	20	128	59.2	180	300	—1.0	—12.0
8	18	121.5	59.0	175	310	±0.	—12.0

	Density			% absorption			
No.	Raw	Cone 10	Cone 14	Raw	Cone 10	Cone 14	Softening point
1	1.79	1.77	1.68	15.0	15.5	15.2	26
2	1.97	1.93	1.88	9.1	12.2	12.3	34–35
3	2.03	1.96	1.84	10.0	11.5	10.4	34–35
4	2.03	1.96	1.84	9.5	11.8	14.0	33
5	2.00	1.89	1.81	9.7	13.0	14.1	33
6	1.92	1.82	1.8	12.8	15.2	15.7	31
7	1.76	1.73	2.83	14.4	17.3	6.8	17
8	1.79	1.73	2.02	15.9	17.4	4.2	17

Samples 2, 3 and 4 have compositions similar to silica brick. 4 and 5 contain an increased CaO content which decreases the refractoriness. 6 contains clay together with CaO. Clay retards the cementing action preventing to some extent the formation of calcium hydro-silicates. Samples 7 and 8 contain fire-clay grog as was specified in the patent of Gürtler. The grog decreases the refractoriness too much. H. G. SCHURECHT

22. Sintering of dolomite. F. I. *Tonind.-Ztg.*, **45,** 442(1921).—Dolomite containing 4% $Al_2O_3 + Fe_2O_3$ can be sintered most easily. The raw dolomite is mixed with coke and the mixt. calcined at 1100°–1280°C. The calcined material is crushed and used in the granular form for furnace linings. It is also made into brick with 5–8% tar as a binder and pressed when hot under a high pressure. H. G. SCHURECHT

23. Uniform high temperature throughout a large volume. E. F. NORTHRUPP. Ajax Electrothermic Corporation. Trenton, N. J. *J. Ind. Eng. Chem.*, **13,** 639(1921).—A description of an Ajax-Northrup high frequency furnace for securing and maintaining a uniform temp. up to 2500°C throughout a graphite chamber (of ½ to 1 cu. ft. vol.) packed in lamp black.

24. Judging sands for foundry use. I. HENRY B. HANLEY AND HERBERT R. SIMONDS. *Foundry*, **48,** 741–6(1920).—Foundry sands may be classified broadly as follows: (1) Moulding sand; (2) core sand; (3) racing sand; (4) fire sand; (5) gravel; (6) high-SiO_2 steel molding sand; and (7) parting sand. (1) is usually a mixt. of quartz, feldspar, and clay, having peculiar properties or holding a bond when "tempered" with a small amt. of H_2O. The term often covers (3) also, the difference in the two being merely one of refinement in the bond property. When refinement of finish is necessary, a specially fine-grained sand is necessary. (2) usually is a straight SiO_2 sand, sometimes carrying 10–35% feldspar. Cohesion is obtained by an organic binder, such

as linseed oil, molasses, dextrin, resin, etc., or a pitch compd. (4) is usually a coarse SiO_2 sand, with only small quantities if any of clay or feldspar. In the foundry it is mixed with fire-clay to make cupola and ladle linings. (5) is a coarse SiO_2 sand combined with clay to make possible its use as a molding sand. Its function is to increase the porosity of a mold. As castings approach the ton size, porosity of the sand in the mold becomes of great importance. (6) is pure quartz and runs from coarse to fine grades. It must be very infusible and is always artificially bonded. (7) is a pulverized fine quartz sand usually of a fineness to pass a 100-mesh sieve. A table is given showing chem. analyses of the different typical sands, and another table shows the results of sieve tests. Analytical methods for detg. SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, and K_2O are given. The refractoriness conferred by the SiO_2 in a sand depends upon whether it is present as such or as a constituent of feldspar. The Fe_2O_3 content often gives a good indication of the amt. of bond in the sand; it may run from 3.5 to 15% in a molding sand. A chem. analysis does not in any way indicate the phys. properties of a molding sand, and, since these properties are the most important, chem. analysis should be supplemented by a mechanical analysis where possible. It commonly consists of a sieve test. In addition, a so-called rational analysis is made to obtain information on the relative amts. of the principal mineral constituents—quartz, feldspar, and clay substance. Sands high in feldspar fuse more readily than those of low content. The quartz content of a good refractory molding sand does not run below 90%. The method of detg. clay substance is one of soln. of sol. material in reagents, and not only the hydrated Al silicate (clay) but other sol. silicates are reported as clay substance. Hence this detn. must be used with care.

The method is as follows: 1 g. of dry, finely ground molding sand is weighed into a 150-cc. beaker and 15 cc. concd. H_2SO_4 are added. The mixt. is stirred well and allowed to digest for 12 hrs. at a temp. high enough to give off acid fumes. The soln. is cooled, dild. with 100 cc. of 10% NaOH soln., filtered through a Gooch crucible and washed with about 50 cc. of 25% HCl. The residue is washed with hot H_2O until free from chloride; it consists of the quartz and feldspar. It is ignited to const. wt. and the clay substance assumed to be equal to the wt. loss over the original sample. The residue is then subjected to an alk. fusion (5 parts of Na_2CO_3) and the SiO_2 removed in the usual way. The filtrate is neutralized with NH_4OH, boiled for a few moments, and filtered. The ppt. is washed with hot H_2O containing a few drops of NH_4OH, then dried and ignited. It is taken as the Al_2O_3 content of the sample. It is calcd. to feldspar by assuming the latter to contain 18.34% Al_2O_3. The amt. of quartz is closely indicated by the difference between the feldspar and the clay, detd. as described above. A more reliable method of detg. the bond is known as the bond absorption test. It consists in detg. the amt. of dye absorbed by the colloidal matter present. The amt. of colloidal matter divided by the surface area of the sand gives the bond "density," which furnishes a much more reliable guide to relative bond strength than any other single quantity. An additional point to consider irrespective of surface area

is grain shape and amt. of voids. The effect of this factor can be detd. to some extent by experience, although the sieve-test data may be used to obtain approx. results. Evenly graduated amts. remaining on the different sieves indicate a low void. The bond absorption test is carried out as follows: 25 g. of the prepd. molding sand are placed in a 500 cc. wide-mouth bottle, and 250 cc. of distd. H_2O are added, together with 5 cc. of 10% NH_4OH. The bottle is sealed with a glass stopper and paraffin wax and rotated for 1 hr. Then 140 cc. of H_2O are added and the soln. is acidified with about 5 cc. of 10% acetic acid. Sufficient dye (crystal violet) is then added to insure a slight excess after complete absorption. The bottle is again sealed and agitated for 2 hrs. The bottle is removed from the machine and allowed to stand for a few hrs. until the coarser particles have settled to the bottom. From the top portion of the liquid 100 cc. are withdrawn and to this portion are added 25 cc. of H_2O and 2 cc. of 10% acetic acid. A 5-g. skein of mordanted cotton yarn is introduced into the liquid and the temp. gradually raised through a period of 40 mins. to 60°, by which time, through careful movement of the skein, all the dye should be removed from the soln. The skein is removed, washed, and dried at 75° and comparison of its color made against a standard set of skeins, the amt. of dye which was not absorbed by the colloidal matter being thus detd. Usually the standard skeins are made by depositing on each of 6 skeins 6, 8, 10, 12, 14 and 16 mg. of crystal violet dye. As a further indication of the bonding value of sands, a transverse strength test is often made. To make this test, 400 g. of molding sand are "tempered" with H_2O up to the point of satn. It is then rammed into a cement briquet mold, having a 1 x 1 in. cross-section at the center. After removal from the mold the specimen is dried over night and then held for 3 hrs. at 100° in an oven. It is tested in a suitable transverse testing machine, with a breaking capacity of from 1 to 150 lbs. per sq. in. A simple easily constructed machine is described. Photographs of 8 typical sands (8 magnifications) are shown. A. L. FEILD (*C. A.*)

25. The coking plant of the Rhenish steel works in Duisburg-Meiderich and the use of silica brick for coke ovens. J. ENGENAUER. *Stahl u. Eisen*, **40**, 1326–35 (1920). CARLE R. HAYWARD (*C. A.*)

26. Standardization of burning. J. H. KRUSON. *Brick and Clay Record*, **59**, 106–110 (1921).—Due to sluggish draft during water-smoking the time of firing ware in periodic kilns is too long and hence expensive. It is possible to remove all of the mechanical H_2O from clays by drying but the ware would be too hot to handle. The H_2O in the kiln atmosphere comes from the fuel as well as from the clay. Coke and hard coal contain 1–3% H_2O; soft coal 3–15%; lignite or brown coal 14–40%; and wood 15–30%. Gas and oil contain but little moisture. The proper draining of the kiln bottom is essential since damp floors and flues mean that more moisture must be evaporated and carried away. Many manufacturers insist on 8–10 burns which is longer than necessary. The continuous kilns have proved that clays can be successfully fired in 120–132 hrs. or less. Rapid firing in some periodic kilns is impossible

because of faulty construction. Ample flue and grate space should be provided to allow a more rapid increase in temp. during water-smoking. By increasing the draft during water-smoking in a periodic kiln the time of firing was reduced from 192 hrs. to 120 hrs. with a saving of 0.18 tons of coal per ton of ware and with an accompanying saving in labor and increased kiln capacity of over 20%. H. G. SCHURECHT

27. Industrial application of powdered fuel. JAS. P. SHAGDEN. *Iron Age*, **107,** 839–42 (1921).—Cf. *C. A.*, **14,** 1028, 3306.—S. discusses the theory of transfer of heat energy and the temp. cycles involved, the design of combustion chambers, and briefly enumerates the processes peculiarly suited to powdered fuel. He advizes against too great optimism in setting up the process without a careful study of conditions involved. J. L. WILEY (*C. A.*)

PATENTS

28. Highly refractory article and method of producing the same. HENRY H. BUCKMAN AND GEORGE A. PRICHARD. U. S. 1,375,077, April 19, 1921. In the manufacture of a refractory composition, or material, the step consists in incorporating zircon into the batch.

29. Manufacture of refractory and insulating products. GEORGES LOUIS DIMITRI AND JULES EDOUARD DELAUNAY. Paris, France. 1,374,493, April 12, 1921. A process of manufacturing refractory and insulating products, comprising mixing together ceramic materials in a powdered state, and moulding the powdered mixture under pressure in a vacuum into the form of articles of definite shape.

30. Kiln and fire-brick therefor. SIMON HENRY HARRISON. U. S. 1,374,203, April 12, 1921. An iron-incased brick-lined calcining chamber or furnace, which consists in wedge shaped bricks having the area of contact between the lining brick and the inclosing casing reduced to flanges only, the structure being sealed against passages of gases longitudinally of the casing and the bricks being held in position by their mutual wedging actions.

C. M. SAEGER, JR.

31. Refractory substances. A. ROLLASON. Brit. 156, 447, April 21, 1920. A refractory material for lining furnaces is made by roasting at about 1800° magnesite or dolomite in granular form with 5–10% of basic slag in an internally fired rotary kiln having a basic lining. From the kiln the material passes into an annealing chamber, where it is allowed to cool slowly.

(*C. A.*)

32. Cooling means for tunnel-kilns. JOHN B. OWENS. U. S. 1,379,714, May 31, 1921. A tunnel kiln having a furnace for delivering heat into the interior of its tunnel and provided with a sealed cooling zone whose side walls are provided with air circulating spaces scaled from the interior of the cooling zone, the spaces being adapted to receive outer air at their lower parts, and to void the air at their upper parts, and being arranged and adapted for the upward passage of the outer air for the purpose of cooling in the inner tunnel walls and taking off the heat radiated from the ware within the cooling zone without direct entry of air into the cooling zone or direct exit of air therefrom.

33. Combustion-chamber for tunnel-kilns. JOHN B. OWENS AND ELLSWORTH P. OGDEN. U. S. 1,378,190. May 17, 1921. A tunnel kiln having a combination chamber at its side, a baffle for the upper part of the combustion chamber where the latter faces the interior of the tunnel, and piers supporting the baffle, the piers being separated by discharge ports or passages through which the heat and products of combustion pass from the combustion chamber to the interior of the tunnel, the baffle being provided with ports which open into the interior of the tunnel at the lower portion of the baffle and communicate with the combustion chamber in the upper portion thereof.

34. Method and apparatus for melting oxids, etc., without contamination. EDWIN FITCH NORTHRUPP. U. S. 1,378,189. May 17, 1921. In the melting of metallic oxids and like chemicals the combination of a crucible composed of a metallic oxid having a melting point in excess of the intended temperature of the melt and a molten body of the metal whose oxid is being treated within the bottom of the crucible.

35. Lining for kilns. ALBERT FRITZ MEYERHOFER. Mannheim, Germany. 1,378,710, May 17, 1921. A lining for the purposes set forth which consists of an inner layer containing a high percentage of corundum combined with an insulating layer of porous brick.

36. Means for cooling tunnel-kilns. JOHN B. OWENS. U. S. 1,377,522, May 10, 1921. A tunnel kiln provided with air circulating flues or ducts extending lengthwise within its walls opposite the space below the platform of the ware conveying means.

37. Method of making clay and graphite crucibles. JEAN HUBERT LOUIS DE BATS. U. S. 1,374,910, April 19, 1921. The method of making crucibles or pots containing clay, which consists in mixing metal of the aluminum-magnesium group in a finely divided form with the material from which the crucible or pot is formed, and molding the same, whereby the crucibles or pots may be burned shortly after molding. C. M. SAEGER, JR.

38. Calcining furnaces. A. V. GOWEN-LECESNE. Brit. 148,497, July 10, 1920. The pat. relates to the manuf. of refractory or abrasive products from siliceous rocks, refractory clays, MgO, dolomite, chrome iron, spinel, agglomerated powders of emery and corundum, and Zr and Ce earths, and comprizes forms of furnace adapted for the complete calcination of the raw materials. A suitable construction is specified. (*C. A.*)

39. Furnaces; cooling. A. BIGOT. Brit. 152,602, Oct. 8, 1920. An app. for calcining, baking, etc., applicable also for cooling materials, comprizes a heat-insulated chamber having hollow walls loosely packed with masses of heat-absorbing material, such as bricks, through which, as also through the chamber itself, hot (or cold) gases are caused to flow. The invention is applicable for *drying clays*, etc., *dehydrating gypsum*, etc., *treating* $NaHCO_3$ *and silica-limestones*, and *baking bread*. (*C. A.*)

White Ware

40. The cause and control of lead poisoning. WILBER S. SLEMMONS. *Mining Sci. Press*, **122**, 427–8 (1921).—Physiol. action is described. An app. is shown for testing the amt. of Pb in the air of industrial plants. Individuals may develop acute plumbism when working in air containing 0.1 mg. of Pb per cu. ft. A preventive is a proper ventilating system. A. H. HELLER (*C. A.*)

Brick and Tile

PATENTS

41. Brickmaking apparatus. PEYTAN ANDREWS. U. S. 1,374,173, April 12, 1921.—An apparatus with the agitating and feeding vat into which the mixture is deposited, a tunnelway having a throat connected with the vat, with a plunger for forcing the material through the tunnelway, a plate feeding mechanism for delivering separating plates to the tunnelway on the recession of the plunger; means for reciprocating the plunger.

42. Artificial stone or brick. WOOTSON L. SANDERSON. U. S. 1,376,464, May 3, 1921. Artificial stone including, in approximately the proportions stated, 5 cubic feet of sand, 3 3/4 pounds of red oxid of iron, 2 1/2 pounds plaster of Paris, 1 1/4 pounds of ocher, 1 1/4 pounds of salt, 10 ounces of sugar, and 95 pounds of cement.

43. Brick-kiln. FRANK MUNHOLLON. U. S. 1,375,719, April 26, 1921. A brick kiln having a series of furnaces spaced about the outer wall thereof, a floor having substantially uniform space therein, transverse passages beneath the floor, and passages connecting these transverse passages with furnaces, and having openings into the transverse passages varied in size with relation to the distance from the furnaces. C. M. SAEGER, JR.

Glass

44. The repair of crystallized glass apparatus. HERBERT BAILEY. *J. Am. Chem. Soc.*, **43**, 1319 (1920).—If an asbestos paper soaked with salt solution be held in the flame in such a position that the sodium vapors envelope the devitrified glass the crystallization will usually disappear by the time that the glass is soft enough to work. ED.

45. The use of acetylene in glass blowing. A. S. COOLIDGE. *J. Am. Chem. Soc.*, **43**, 1319 (1921).—An ordinary glass-blower's torch fed with acetylene and compressed air gives a flame in which Pyrex glass can be worked rapidly and easily. ED.

46. Bottle manufacture in Spain. ANON. *Le Verre*, **1**, 133–35 (1921). ED.

47. The world crisis in the glass industry. ANON. *Le Verre*, **1**, 137–8. —A description and comparison of industrial conditions in Belgium, France, England, Germany, Italy and the U. S. ED.

48. Silica glass. G. FLUSIN. *Chimie & industrie*, **3**, 729–49 (1920).—In this article complex relations existing among the various forms of silica, cryst. and amorphous, are discussed in detail. Amorphous silica is the form stable at high temps., quartz being converted to silica glass by rapidly-heating above 1470°, tridymite at 1670° and crystobalite at 1625–1710°. Silica glass on being heated for some time at 1500° devitrifies, owing to recrystn. to crystobalite. Conversion to tridymite is brought about by heating to 900–1470° in the presence of KCl. Fused quartz is very viscous even at temps. well above its melting point, It begins to volatilize rapidly at 1750°, while it is still pasty, so that it is very difficult to obtain silica glass free from bubbles. The following physical properties of silica glass are given: d. 2.21, coeff. of expansion 49×10^{-8}, sp. heat 0.20–0.28, heat of fusion (by calcn.) 64–6 g. calories per g. It is transparent down to $\lambda=0.220\ \mu$; n_D 1.4585, dispersion 0.0068, resistivity at 15–150°, 2×10^{8} megohms per cm., at 800°, 20 megohms, modulus of elasticity 6.6 kg. per mm.^{2} Silica glass is permeable to gases especially to H and at high temps. It is not appreciably sol. in water even at 100°, nor in strong acids except hydrofluoric and phosphoric. It is not attacked by salt solns. but is appreciably sol. in alkalies, especially when hot. It reacts with metallic oxides as CuO when heated to 900°. J. S. LAIRD (*C. A.*)

49. Glass paper. RASSER. *Kunstoffe*, **10**, 121–2, 139–40 (1920).—A general description of the manuf. C. J. WEST (*C. A.*)

50. A new principle in blow pipe construction. H. G. BECKER. Royal Dublin Society. *Nature*, June 2, **1921**, p. 446. The essential features of a quick change blow-pipe operating at constant air pressure are discussed and the necessity of different bores for the different flames is emphasized. The tubular shape common to all hitherto existing blow pipes is shown to be unnecessarily cumbersome, and is therefore abandoned. A form of blow-pipe giving a great range of flames (including a flat blow-pipe flame) each provided with an air jet of suitable size and allowing of instantaneous change was described and exhibited in operation. WM. M. CLARK

PATENTS

51. Frosted glass. T. UEDA OF KYTO. Brit. 144,739, 1919. *Science Abstracts.*, Sec. B., April 29, **1921**, p. 177. By coating glass with alkali silicates, basic lead silicates or lead salts which when heated react with the glass to form a product decomposable with hydrochloric, sulphuric or nitric, as well as hydrofluoric acids, a frosted surface is obtained.

WM. M. CLARK

52. Glass furnaces. HARVEY GAS FURNACE CO., LTD. E. W. HARVEY. Brit. 162,232. Ill. Off. Jour. Pats., June 15, 1921, p. 2347. In a gas fired melting furnace for glass heated by one or more reversible flames, supplementary ports are provided near the gathering holes through which a portion of the heating gases is drawn, under the control of dampers, by a draught stronger than that serving the main ports. These may be connected directly to the chimney or through regulators. WM. M. CLARK

53. Glass manufacture. M. MEUNIER. Brit. 162,193. May 8, 1920. Ill. Off. Jour. Pats., June 15, 1921, pp. 2334–6. Describes, with four drawings, the mechanical details of a glass blowing machine; for making hollow glass articles, particularly those, such as siphons, which must withstand internal pressure. It is of the type in which the article during formation is carried by a table, rotating intermittently, to the mechanisms for performing the various operations of blowing. WM. M. CLARK

54. Glass manufacture. A. A. KELLEY AND B. D. JONES. London, Brit. 160,495. Nov. 20, 1919. Ill. Off. Jour. Pats, May 19, 1921, p. 1723. In the manufacture of glass, vitreous enamels and glazes sodium pentaborate is substituted for borax or boric acid and the necessary adjustment of the alkali content is made in any suitable manner. WM. M. CLARK

55. Glass. W. G. CLARK. N. Y. City and L. N. BURNER, Locarno, Switzerland. Brit. 161,192. Ill. Off. Jour. Pats. May 25, 1921, p. 1978. To fine molten glass extra heat is supplied by passing an electric current thru the melt, preferably A. C. current of 60 cycles or higher. The necessary apparatus is described and sketched. WM. M. CLARK

56. Glass-grinding machine. EDWARD A. RYON. U. S. 1,373,835, April 5, 1921. A glass grinding machine comprising a grinding wheel, a driving shaft, a pulley thereon, a clutch for coupling the pulley to the shaft, a spindle, a ratchet and pawl connection between the shaft and the spindle for rotatively advancing the spindle step by step, and annular cam on the driving shaft, and a rocking lever actuated by the annular cam to move the spindle toward and from the cutting wheel.

57. Glass-severing. KARL E. PEILER. U. S. 1,379,594. May 24, 1921. In a machine having reciprocatory shear blades for cutting molten glass, mechanism for independently tilting each of the shear blades downward while they are cutting.

58. Method of ornamenting sheet-glass. MICHAEL J. HOWARD. U. S. 1,375,251, April 19, 1921. This method comprises placing colors on the surface of a liquid, dipping an object into the liquid to cause the colors to be applied to the surface of the object and also to be removed from the liquid, removing the object from the liquid, then applying a coating to the colored surface of the object, and then separating the surface of the liquid which has the colors removed, from the remainder of the surface.

59. Glass-working machine. FRANK L. O. WADSWORTH. U. S. 1,375,336, April 19, 1921. An apparatus for cutting streams of viscous materials comprising a pair of cup-shaped mating members one having a cutting edge capable of entering the stream and the other having a projecting cutter capable of entering the stream overlapable upon the first-mentioned cup.

60. Process for making articles of quartz glass. JOHN SCHARL. U. S. 1,375,-657, April 19, 1921. The process of making articles of quartz glass consisting in heating the quartz into a plastic mass in an electric resistance furnace about a resistance core, closing the bottom of the fused mass, then removing the same from the furnace together with the hot core and blowing the mass out into desired shape.

61. Glass-drawing apparatus. JOHN J. BLOXSOM AND ELMER E. MYERS. U. S. 1,375,818, April 26, 1921. An apparatus for drawing glass cylinders, with a turn table provided with a molten glass container, an air conduit extending through the table and container, a verticle disposed air supply pipe below the table provided with a bottom discharge opening, the top of the pipe being adapted to register with the bottom of the conduit when the glass container is in drawing position, a closure for the discharge opening, and means coördinated with the movement of the table for opening the closure to permit the discharge of broken glass from the air supply pipe.

62. Glass-tank. ARTHUR E. SPINASSE. U. S. 1,375,941, April 26, 1921. A glass drawing tank, with floating drawing ring, a flange projecting up from the top of the drawing ring, and a water-cooled ring-holding means adapted to engage the ring on its top without the flange to hold it in drawing position while the flange protects the glass within the ring from the chilling effect of the water-cooled ring-holder device.

63. Method of and apparatus for cutting sheet-glass. JOSEPH P. CROWLEY. U. S. 1,377,320, May, 10, 1921. A glass cutting apparatus with a device for scoring a sheet of glass. A method of cracking glass, which consists in extending a score along the surface thereof, and concomitantly applying a series of taps or blows progressively along the score at a substantially constant distance from the point to which the score has been extended, thereby progressively cracking the glass along the score.

64. Glazing system. ALFRED ERNST DROWN. England. 1,377,673, May 10, 1921. A reinforced glazing bar, and glass sheets supported thereon, with means for forming a fixed part of the bar and secured to the reinforced member thereon to retain the glass sheets in position.

65. Process and apparatus for severing sheet-glass. HARRY G. SLINGLUFF. U. S. 1,373,533, April 5, 1921. A process of severing a continuously formed sheet of glass which consists in applying a pair of electrically heated transversely extended members to the opposite sides of the sheet at the same time.

66. Machine for the automatic and continuous manufacture of glass bottles. GEORGE ORLANDO TAGUE. England. 1,373,272, March 29, 1921. A machine for the manufacture of glassware, with a mold charging and forming device and a separate blowing device, with intermediate transfer device having an article carrying means comprising opposing gripping members movable up and down, and means for actuating the gripping members having an up and down movement independently of the corresponding movement of the gripping members whereby an article carried by one of the first mentioned devices is engaged and an article at the opposite side is simultaneously disengaged for deposit upon the other of first mentioned devices.

67. Method of finishing glass. LEE SHOWERS. U. S. 1,373,532, April 5, 1921. The method of finishing smoothed relatively opaque glass which consists in employing members with a polishing powder approximating in color that of the glass and maintaining the members at a degree of drying such as will cause a burning of the glass.

68. Device for severing glass. HARRY F. HITNER. U. S. 1,373,728, April 5, 1921. A glass cracking off device, a heating chamber, a flexible cracking off member mounted for movement into and out of the chamber, and with means for heating the chamber.

69. Glass-delivering apparatus. KARL E. PEILER. U. S. 1,373,202, March 29, 1921. An apparatus with means for feeding molten glass with number of sets of receptacles; a movable chute having an inclined glass conducting surface, and automatic device actuated in predetermined order and time for moving the chute to bring the same inclined conducting surface successively into delivering alignment to the receptacles of the different sets.

70. Glass-grinding machine. EDWARD A. RYON. U. S. 1,373,836, April 5, 1921. A glass grinding machine comprising a work holder, with a mechanical movement producing an oscillatory adjustment of the work holder, with means for reciprocating the work holder between each oscillatory adjustment thereof, device for rotatively adjusting the work about an axis at right angles to the axis of oscillation, and means for reciprocating the spindle.

71. Machine for rolling plate-glass. HARRY A. REYNOLDS. U. S. 1,375,-014, April 19, 1921. A glass mechanism having a table, a roll mounted on the table for movement longitudinally thereof, a pair of roller members extending transversely on the table at its end and adapted to receive the roll and support it for rotation out of contact with the table, whereby the roll is turned while in such position. C. M. SAEGER, JR.

Enamels

72. The penetration of iron by hydrogen. (Possible relation to fish scaling.) T. S. FULLER. *Gen. Elec. Rev.*, **23**, 702–711 (1920).—The penetration of H into iron was found to be as high when exposed to 1% sulphuric acid solution as when made the cathode during an electrolysis with a similar solution. At 20°C, 2 cc. of H penetrated a seamless iron tube, 12″ long x $^{11}/_{16}$″ outside diameter and $^{1}/_{16}$″ wall, during 48 hrs. Passage of H through iron is apparently facilitated by the presence of a coating of tin and retarded by one of zinc or copper. 1% potassium bichromate added to sulphuric acid prevents the passage of H through iron for at least 96 hrs. Ed.

Cement, Lime and Plaster

73. A new type of automatic cement tester. T. Y. OLSEN. *Proc. Am. Soc. for Testing Materials*, **20**, II, 408–10 (1920).—The app. is similar in a no. of respects to the ordinary shot machine. The load is applied by a lever carrying a heavy weight. When not in use, this lever is supported at one end by a column of liquid confined in a vertical cylinder. When a briquet is in position, the lever is set in motion by turning a thumb screw, which allows the oil to float from the cylinder, and the load is applied at the rate of 600 pounds per min. J. C. WITT (*C. A.*)

74. Report of Committee C-11 on gypsum. WARREN E. EMLEY, *et al.* *Proc. Am. Soc. for Testing Materials*, **20**, I, 380–6 (1920).—The report includes recommendations of the committee on revisions of specifications as follows:

Tentative specifications for gypsum, tentative specifications for calcined gypsum, tentative methods for tests of gypsum and gypsum products, and specifications for gypsum plasters. In the tentative methods for tests of gypsum and gypsum products are considered the temp. of drying, the size of screen used for fineness detn., the chem. detn. of SiO_2 and MgO, the method of calcg. results, the detn. of normal consistency by means of the Southard viscosimeter, water-carrying capacity, dry bulk, wet bulk, time of setting, tensile strength and compressive strength. J. C. WITT (*C. A.*)

75. Tentative methods for tests of gypsum and gypsum products. ANON. *Proc. Am. Soc. for Testing Materials*, **20**, I, 634–46 (1920).—The tests considered are free H_2O in gypsum, fineness, chem. analysis of gypsum and calcined gypsum, microscopic examn. of gypsum and calcined gypsum, precaution for physical tests, normal consistency of calcined gypsum, water-carrying capacity, detn. of dry bulk, detn. of wet bulk, time of setting, tensile strength, compressive strength, and sand-carrying capacity of calcined gypsum. The methods for chem. analysis include prepn. of sample, detn. of combined H_2O, CO_2, SiO_2, Fe_2O_3, Al_2O_3, CaO, MgO, SO_3 and Cl and directions for calcg. results. J. C. WITT (*C. A.*)

76. Plastic gypsum plaster. WARREN E. EMLEY. *Chem. Met. Eng.*, **24**, 740–1 (1921).—Advance description of a method of prepg. gypsum plaster to obviate the necessity of adding lime to increase its plasticity; the patent when issued is to be for free public use in the U.S.A. The method consists in fine grinding the calcined gypsum in a ball or tube mill, at the same time *preventing* the escape of water, so that the product leaving the mill contains 9 parts by wt. H_2O to 136 parts $CaSO_4$, or about 6.2% H_2O. "If the grinding is sufficient to liberate all of the water [*i. e.*, with air passing through the mill] the resultant product is sol. anhydrite. This is a peculiar form of anhydrous $CaSO_4$ and differs from the mineral anhydrite in its great affinity for water—a very short exposure to moist air is sufficient to change it back to the hemi-hydrate. When calcined gypsum is subjected to grinding under such circumstances that water is not permitted to escape from the system, an entirely new product results. No satisfactory explanation has yet been evolved but the fact remains that the product is plastic. Up to a certain limit, the degree of plasticity seems to depend upon the duration and speed of grinding. JEROME ALEXANDER (*C. A.*)

77. Lime-mortars: Solution and conversion of solid substances into colloids. V. KOHLSCHÜTTER AND G. WALTHER. *Z. Elektrochem.*, **25**, 159–83 (1919).—The rate at which CaO, prepd. from $CaCO_3$, $Ca(OH)_2$, and Ca oxalate, resp., combines with water vapor at the ordinary temp. has been detd. The vol. changes and the amt. of water taken up have also been detd. The rate of absorption is shown to differ with the various samples of CaO. Further, the rate of sedimentation of $Ca(OH)_2$ has been measured for $Ca(OH)_2$ prepd. by slaking lime in water or solns. of $CaCl_2$, $Ca(NO_3)_2$, NaCl, KCl, KNO_3, NaOH, AcONa, KCNS, NH_3, NH_4 oxalate, and Na carbonate of various concns. (*C. A.*)

78. Some new features in lime kiln construction. RICHARD K. MEADE. *J. Ind. Eng. Chem.*, **13,** 722–27 (1921).—**Heat losses.** An analysis of the various sources of heat losses is given. These amt. to about 60% even in good practice.

The flame kiln. An oval *cross sec.* above fire box with two sides drawn in slightly is preferred. The *ht. of shaft* should be as great as draft conditions will permit. A quick acting tight fitting *charging arrangement* should be used. A stone *charging bin* at the top of the shaft should be employed. A steel *cooling cone* is recommended for coal fired kilns. For gas fired kilns the heat from the cooling lime should be used to preheat the air used for combustion. A *quick acting draw* on the cooling cone is described. It cuts down to a min. the excess air entering the kiln during drawing. A *hand stoker* increases greatly the capacity of the kiln, cuts in half the labor of stoking, reduces fuel consumption, and eliminates the core. A layer of sil-o-cel between the shell and the brick reduces radiation losses. Concrete *shells* and concrete *pedestals* are recommended. Keyed fire blocks 17 x 11 x 15 x 18 in. are pref. to brick for *arch construction*. The life of the cooling cone is materially increased by air cooling or water jacketing the upper part.

Rotary kiln. *Pulverized coal* is preferable to producer gas. The *diam. of the stone* should be smaller than 2.5 in. and larger than 0.25 in. *Dust* should be eliminated by washing or screening. The waste heat in the gases leaving the kiln is large and should be recovered with *waste heat boilers* if the power can be used. A kiln burning 4 tons of lime per hr. would be good for 180 h. p. A *rotary cooler* through which the air for combustion passes is recommended. Sil-o-cel blocks should be used between the brick lining and the steel shell of the rotary kiln to reduce heat losses. *Chem. control* of the waste gases and *pyrometers* installed in the wall of the kiln are recommended. ED.

79. Theory of iron Portland cement. F. SORCEL. *Rev. Mat. Constr. Trav. Pub.*, **136,** 3 (1921).—Iron Portland cement is a ground mixture, composed of 70% clinkers, made by burning slag and lime stone together, and of 30% granular basic slag. Passow has found that the strength of the cement depends greatly upon whether the base slag is in a vitrified or devitrified state. Some base slags, shown by microscopic examination to be devitrified, gave poor cements. The same base slags were then fused and supercooled by being poured into cold water. This treatment gave clear vitrified products. The resistances to compression and tension were greatly increased by using these vitrified products for cements. LOUIS NAVIAS

80. "Mazout" (burning oil) as fuel for lime-kilns. A. STOLL. *Rev. Mat. Const. Trav. Pub.*, **142,** 129–130 (1921).—"Mazout," the liquid residue from the distillation of benzine and kerosene from petroleum can be used for firing vertical lime-kilns. Six burners situated in the mouth of the kiln are used. Sketches of kiln and burner given. LOUIS NAVIAS

81. The use of fused cement in reinforced concrete structures. L. MALPHETTES. *Rev. Mat. Constr. Trav. Pub.*, **141,** 105–106 (1921).—M. criticizes Magny's comparison of cost figuring of reinforced concrete structures

made (1) with fused cement and (2) with Portland cement. For Portland cement, Magny uses the official specifications for a compression strength of 28% of that obtained after 90 days setting for a 1 : 3 mortar, namely, about 35 kgs. per sq. cm. For the fused cement, Magny allows a compression resistance of 150 kgs. per sq. cm. which is about 35% of the resistance measured by him. M. suggests that two similar structures be built, using Portland cement in one and fused cement in the other. By testing them similarly, the proper coefficients may be determined for use in calculating their comparative costs. LOUIS NAVIAS

82. Concrete-cement brick. M. BOUSQUET. *Rev. Mat. Constr. Trav. Pub.*, **140,** 92–95 (1921).—Brick is made of a mixture of cement and sand. Photographs and descriptions of presses and concrete mixers are given. LOUIS NAVIAS

83. Progress in cement making. L. MALPHETTES. *Rev. Mat. Constr. Trav. Pub.*, **140,** 81–84 (1921).—Three new types of cement have lately appeared. (1) Fused cement—bauxite and lime are intimately mixed and then fused. (2) Hydraulic lime is converted to clinkers by heating in a rotary kiln. The mass is quickly cooled, and then ground. (3) Schist cements—coal-mine schists, having roughly the composition, fixed C and volatile matter 40%, SiO_2 36%, Al_2O_3 15%, Fe_2O_3 9% have been mixed with lime and burned, yielding a good cement. 100 kgs. schist and 240 kgs. lime yield 200 kgs. cement. The 40 kgs. of fixed C and volatile matter yielded by the schist is the only fuel used in the kiln. Le Chatelier's formula for the formation of $SiO_2.3CaO$ in artificial cements does not hold for fused cement. Bied states that the latter contains $SiO_2.2CaO$ and $Al_2O_3.CaO$. Neither the theories nor the proper conditions for reaction for any of the above cements have been worked out. M. puts forward these examples to show the need of an industrial cement research laboratory in France. LOUIS NAVIAS

84. Economic quarry exploitation. D. S. *Rev. Mat. Constr. Trav. Pub.*, **138,** 49–53 (1921).—Plans and description of a plant for using quarry waste. LOUIS NAVIAS

85. Modern plaster plant. M. J. DUCHEZ. *Rev. Mat. Constr. Trav. Pub.*, **138,** 54–56; **139,** 76–78 (1921).—Description, photographs of machinery and plans of an automatic plant. LOUIS NAVIAS

86. The sudden disintegration of clinkers on cooling in the air. J. DAUTREBANDE. *Rev. Mat. Constr. Trav. Pub.*, **138,** 46–48; **139,** 72–73 (1921).—Clinkers directly from the kiln have been found to disintegrate either (*a*) partially or (*b*) totally. This will occur when the proportions of the ingredients are not balanced so as to give the proper ratios for the $SiO_2.3CaO$ compound necessary for a good cement. $SiO_2.2CaO_2$ is not desirable in a cement for it has no bonding properties. In partial disintegration (*a*) the ratio may be upset by the introduction of SiO_2 from the fuel, if it has a high ash content (50% of which may be SiO_2) and from a furnace brick lining that has been under fired. Poor heat distribution and under firing will produce $SiO_2.2CaO$ and free lime, the temp. not being high enough to produce $SiO_2.3CaO$. When

the whole mass falls to dust (*b*) the cause may be due to under or over burning; in the latter case the $SiO_2.3CaO$ is changed to $SiO_2.2CaO$. Lack of sufficient Fe_2O_3 will cause disintegration for Fe_2O_3 helps in the formation of the $SiO_2.3CaO$. Either (*a*) or (*b*) makes a poor cement. If, however, they are plunged into cold water, the clinkers remain intact, and when ground, give fairly stable cements. D. states that this shows that $SiO_2.2CaO$ exists in two allotropic forms. LOUIS NAVIAS

87. Wetting of coal for continuous lime kilns. LE GEUN. *Rev. Mat. Constr. Trav. Pub.*, **136**, 1–2; **137**, 21–23 (1921).—Water vapor is used in the burning of lime and cement, as a means of combustion, and as an accelerator in the reaction $CaCO_3=CaO+CO_2$. Water is found in the fuel, and in the lime stone as adsorbed moisture and as water of constitution. As these quantities are not sufficient, the deficit is made up by introducing into the kiln wet powdered fuel. Part of this water passes through the kiln undecomposed, heating up the colder mass on condensation, or abstracting heat on vaporization. The heated fixed carbon of the coal combines with the remaining water vapor, $C+H_2O=CO+H_2$, forming water gas, which burns. If too much water is introduced there will be a great absorption of heat due to the vaporizing of the water, and as a result the kiln will cool, and the product will be only partly decomposed. *Limestone loses its CO_2 faster and at a lower temp. in a current of water vapor, than in a current of dry air.* The following equation may be used to determine the quantity of water to be added to the fuel to take care of all reactions for the best results.

$$A = 1.5\,C - h - \frac{100}{d}\,(10H - B)$$

Where A = litres of water added to wet 100 kgs. of fuel. C = % of fixed carbon in fuel, h = % of water in fuel, d = no. of kgs. of fuel used for 1000 kgs. of crude limestone. H = % of water adsorbed and combined in the limestone. B = coefficient which takes into account the variations of CO_2 found in the limestone. Experimentally B has been found to be 50 for fat limestones (containing 0–4% clay), 30 for hydraulic limestones (containing 10–12% clay) and 10 for natural limestone cements (containing 20–22% clay). As raw clay contains water of constitution, less water B has to be added if the % of clay in the limestone is higher. 12 gms. of C theoretically combine with 18 gms. of H_2O, so the ration of 1 : 1.5 is indicated in the formula. Example: A coal contains 72% fixed carbon and 3% moisture, so $C = 72$, $h = 3$. 133 kgs. of coal are needed for 1000 kgs. of crude limestone, hence $d = 133$. The limestone averages 10.5% adsorbed moisture and 1.5% water of constitution, so $H = 12$. $B = 30$. $A = (1.5 \times 72) - 3 - \frac{100}{133}\,(10 \times 12) - 30 = 37.5$ litres. LOUIS NAVIAS

88. A new artificial cement plant. L. MALPHETTES. *Rev. Mat. Constr. Trav. Pub.*, **138,** 41–43; **139,** 66–71 (1921).—A general description, plan, and some photographs of the plant of the "Societe des chaux et ciments du Languedoc" at Ranteil, France, producing 20,000 tons annually.

LOUIS NAVIAS

89. Urgent request for a cement laboratory. J. BIED. *Rev. Mat. Constr. Trav. Pub.*, **138,** 43–45; **139,** 61–63 (1921).—A plea to the cement manufacturers (of France) to form a joint laboratory where research work may be systematically carried out. The present ignorance of the properties of the silicates and aluminates of calcium and of the mechanism of the many reactions occurring in the preparations and setting of cements, is emphasized.

LOUIS NAVIAS

90. Cement tile. M. CHARPENTIER. *Rev. Mat. Constr. Trav. Pub.*, **139,** 63–66; **140,** 87–89 (1921).—Composition: Artificial cement 22.3–24.2%, washed sand (3 mm. screened) 67.1 to 69.7%, color oxides 0.5%, water 7.5–8.2%. Such tile have fair resistance to compression, are interchangeable, impermeable to water, non-porous, withstand freezing and rapid heat treatments, hold color, mixed with the body or as a glaze well, and look like terra cotta, in place of which they may be used. LOUIS NAVIAS

PATENTS

91. Process for controlling the setting of cement products. CHARLES L. NORTON. U. S. 1,379,204, May 24, 1921. The method of producing a flat relatively thin stone-like body of hydraulic cement of uniform exterior appearance and water absorbtive capacity which comprises confining the same during the setting operation between two opposite restraining surfaces and maintaining an atmosphere of approximately 90 per cent humidity about the edges thereof. (*C. A.*)

92. Keene's cement. W. HOSKINS. U. S. 1,370,968, Mar. 8. Keene's cement stock is produced by passing finely subdivided gypsum continuously to neutralize all acidity. (*C. A.*)

93. Cements. H. D. BAYLOR. Brit. 155,431, Nov. 8. 1919. Cement is rendered slow-setting, plastic, and waterproof by adding CaO and sufficient water to hydrate. (*C. A.*)

94. Quickly solidifying cement. R. OGAWA. Japan 36,334, May 7, 1920. Clay, containing above 60% SiO_2, above 20% Al_2O_3 and below 10% Fe_2O_3 is mixed with lime in the ratio $CaO/(SiO_2 + Al_2O_3 + Fe_2O_3) = 2$ and the mixt. is burned at 1500–1550° to a clinker, and then mixed with 4% mixt. of natural gypsum and plaster of Paris in the ratio 3 : 1, crushed and sieved. The product solidifies completely within 3 hrs. (*C. A.*)

95. Magnesia cement. M. ÔURA. Japan 35,971, March 12, 1920. The cement is prepd. by mixing together (1) and (2). (1) Mixt. of 60 parts MgO and 10 parts of fibrous substance of vegetable or animal origin, *e. g.*, chaff or powdered cork. (2) Ten parts of soln. of powdered *Hydsome rivieri* and *Gloiopeltis furcata* are mixed with 15 parts asbestos or kieselguhr, dried and powdered and mixed with the proper pigment and 5 parts of burnt alum. (*C. A.*)

96. Artificial stone. R. SHINYA. Japan 36,376, May 13, 1920. The stone is prepd. by thoroughly mixing 1.8 l. magnesite, 1.08 l. ZnO and 0.72 l. glass powder with 1.44 l. $MgCl_2$ soln. (30° Bé). (*C. A.*)

BOOK

97. Riepert: Zement-Kalender 1921. Charlottenburg: Zementverlag. 382 pp. . M10.50. For review see *Tonind.-Ztg.* **45,** 104 (1921). (*C. A.*)

ACTIVITIES OF THE SOCIETY

Amendment to Rules

September 23. The following amendment to rules was carried, 115 votes being cast: 106 affirmative, and 9 negative.

In Article II, MEMBERSHIP, section (1) was amended to include the words, "Industrial Association Members." Section (8) was amended to include the words, "Industrial Association Members." A new paragraph was inserted: "Industrial Association Members must be organized groups of manufacturers, who being interested in the advancement of ceramic arts and sciences shall make, for this purpose, such financial contributions as are prescribed in Article III."

In Article III, DUES, a new paragraph reads: "Industrial Association Members shall pay such annual dues in monthly installments or single payment, as shall be agreed upon by the Association and the Board of Trustees, but such dues shall not be less than $480.00 annually."

New Members received during September

Associate Resident

Bales, Cecil E., Louisville Fire Brick Works, Highland Park, Ky.

Burt, N. P., Great Western Stove Co., Leavenworth, Kansas.

Doane, G. Earl, Poplar Bluff, Mo., Doane Consulting Service.

Jackson, Wynne L., 111 S. Kilpatrick Ave., Chicago, Ill., Metallurgist and Chemist, Wolff Mfg. Co.

Montgomery, R. A., Springfield Paving Brick Co., Springfield, Ill.

Quay, Paul Q., 15620 Euclid Ave., East Cleveland, Ohio, Cleveland Metal Products Co.

Rennieburgh, Cedric L., 625 W. Main St., Zanesville, Ohio, American Encaustic Tiling Co.

Rushmore, Murray, 120 West 8th St., Plainfield, N. J.

Stamm, Charles L., 212 W. 2nd St., Mt.Vernon, N. Y., Ward Leonard Electric Co.

Wright, M. H., Tennessee Enamel Mfg. Co., Park Ave. & Railroad, West Nashville, Tenn.

Associate Foreign

Kanashima, Shigeta, Tokio Technical College, Asakusa, Tokio, Japan.

Maruyama, Junkichi, 7 Icchome, Gojotori, Chikko, Osaka, Japan, Kagoshima Electric Railway Co.

Corporation

The Strong Manufacturing Company, Sebring, Ohio.

NECROLOGY

Chester L. Sharp, president of the Sharp-Schurtz Co., died Thursday, August 25th, 1921, from an attack of pleural-pneumonia contracted while attending the meeting of the Merchant's and Manufacturer's Exposition at Lancaster, Pa. Mr. Sharp started work in the glass industry as mechanical engineer for the Columbus Glass Company at Lancaster and later became designing and construction engineer for Ball Brothers Company of Muncie, Indiana. Returning to Lancaster as secretary of the Frink Laboratories and the Frink Pyrometer Company, he, in partnership with P. P. Schurtz, purchased the Frink laboratories when Mr. Frink departed for Europe. Mr. Sharp's sudden death will be felt as a severe loss in the glass industry.

AMERICAN CERAMIC SOCIETY

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Vice-President: Fred B. Ortman, Tropico Potteries, Inc., Glendale, Cal.
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Charles Engelhard, Inc.

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Edward Ford Plate Glass Company
French China Company
Frink Pyrometer Company

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Gillinder Brothers
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Mosaic Tile Company

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Norton Company

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Old Bridge Enameled Brick & Tile Co.
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Pennsylvania Pulverizing Company
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Perth Amboy Tile Company
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Phoenix Glass Company
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Saxon China Company
Sebring Pottery Company
Smith-Phillips China Company
Square D Company
Standard Pottery Company
Standard Sanitary Mfg. Company
Star Porcelain Company
Stark Rolling Mill Company
Steubenville Pottery Company
Stockton Fire Brick Company
Streator Clay Mfg. Company
Strong Mfg. Company

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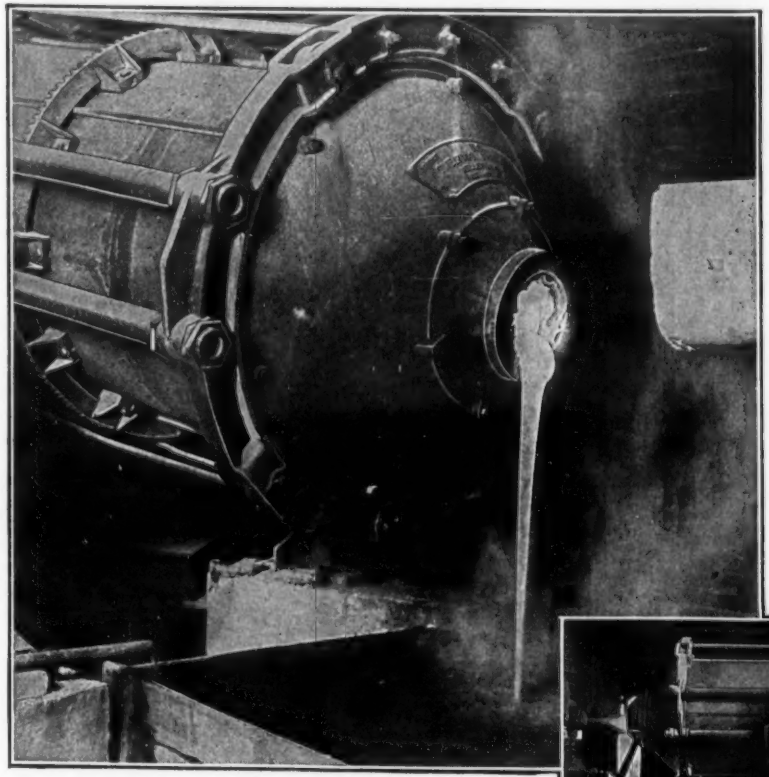
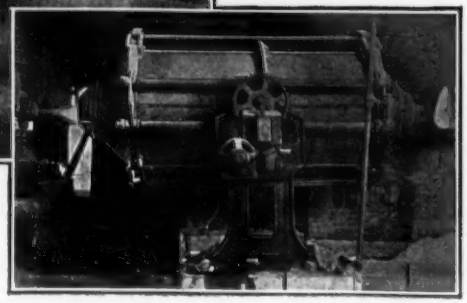
Universal Clay Products Company

Veritas Firing System
Vitro Manufacturing Company
Vodrey Pottery Company

Wahl Company
Warwick China Company
Washington Brick, Lime & Sewer Pipe Co.
West End Pottery Company
Western Stoneware Company
Whitall-Tatum Company

taken in the plant of Ingram-Richardson Mfg. Co., Beaver Falls, Pa.
12-21
U. S. SMELTING FURNACE CO.
BELLEVILLE, ILLINOIS





These illustrations made from photographs taken in the plant of Ingram-Richardson Mfg. Co., Beaver Falls, Pa.

12-21

"Our U. S. Enamel Furnaces Increase Output 25% per day at a Saving of 50% in Fuel Cost."

Ingram-Richardson Mfg. Company claim those remarkable results for their U. S. Enamel Furnaces. With four U. S. Furnaces operating at their plants at Frankfort, Indiana, and Beaver Falls, Pa., they are saving thousands of dollars yearly in fuel and labor.

Their white and colored enamels are smelted in quick time, with low loss. The work is easy and sure. The Furnace is under perfect scientific control. The melting process is visible. The Furnace rotates while melting and tilts when pouring. Linings last longer and cost less.

The U. S. Enamel Furnace is saving money over the old brick smelter in the Ingram-Richardson Mfg. Company plant. It will do the same for you.

Let the U. S. Furnace melt your enamel.

Write for specifications and prices on 60 lb., 150 lb., 400 lb., 750 lb., and 1200 lb. Enamel Furnaces. We will send photographs and list of users where furnaces are in operation.

THE
U. S. SMELTING FURNACE CO.
BELLEVILLE, ILLINOIS

Proof!

BUCKMAN & PRITCHARD, INC.
MINERS AND MANUFACTURERS
MINERAL CITY, FLORIDA, U.S.A.
NEW YORK CITY

February 17, 1921.

Mr. Kenneth E. Ward,
170 Roseville Avenue,
Newark, New Jersey.

Dear Sir:

It might be of interest to you to know that we have had very gratifying results from our full page advertisements in the Journal of the Ceramic Society.

We know of no other trade or class publication that would have so successfully introduced our firm to the particular class of people we wish to reach.

Yours very truly,
BUCKMAN & PRITCHARD, INC.
By G. A. Pritchard
2nd Vice-President.

DHC
Mr. G. A. Pritchard.

Does this Show The "Pulling Power" of the Journal?

BUYERS' GUIDE

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General Ceramics Co.
Alumina (Hydrate and Calcined)
Pennsylvania Salt Mfg. Co.
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Chambers Brothers Co.
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Chambers Brothers Co.
Automatic Stove Rooms
Philadelphia Drying Mch. Co.
Ball Mills
Abbé Engineering Co.
Crossley Machine Co.
Hardinge Co.
Mueller Machine Co., Inc.
Blowers (Pressure)
Abbé Engineering Co.
Bolting Cloth
Abbé Engineering Co.
Brick Making Machinery
Chambers Brothers Co.
Caustic Soda
Pennsylvania Salt Mfg. Co.
Ceramic Plant Equipment
Abbé Engineering Co.
Chambers Brothers Co.
Crossley Machine Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.
Philadelphia Drying Machinery Co.
Proctor and Schwartz, Inc.
Ceramic Chemicals
Drakenfeld Co., B. F.
Harshaw, Fuller and Goodwin Co.
Paper Makers Chemical Co.
Roessler and Hasslacher Chemical Co.
Vitro Mfg. Co.
Clay (Ball)
Goebel & Co., J
Johnson Porter Clay Co.
Clays (China)
Edgar Brothers Co.
Drakenfeld and Co., B. F.
Goebel & Co., J.
Paper Makers Chemical Co.
Roessler & Hasslacher Chemical Co.
Clay (Electrical —Porcelain)
Edgar Brothers Co.
Johnson Porter Clay Co.
Paper Makers Chemical Co.
Clays (Enamel)
Goebel & Co., J.
Clay (Fire)
Edgar Brothers Co.
Goebel & Co., J.
Paper Makers Chemical Co.
Grand View Fire Clay Mines
Clay (Pot, Tank Blocks)
Goebel & Co., J.
Clay (Potters)
Goebel & Co., J.
Clay (Sagger)
Edgar Brothers Co.
Grand View Fire Clay Mines
Johnson Porter Clay Co.
Paper Makers Chemical Co.
Clay Handling Machinery
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.
Clay Miners
Edgar Brothers Co.
Grand View Fire Clay Mines
Johnson Porter Clay Co.
Clay Washing Machinery
Crossley Machine Co.
Mueller Machine Co., Inc.
Clay Working Machinery
Abbé Engineering Co.
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.
Colors
Drakenfeld and Co., B. F.
Harshaw, Fuller and Goodwin Co.
Roessler and Hasslacher Chemical Co.
Vitro Mfg. Co.
Conditioning Machinery
Philadelphia Drying Machinery Co.
Conical Mills
Hardinge Co.
Conveyors (Clay, Sand, Brick, etc.)
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Philadelphia Drying Machinery Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.
Controllers (Automatic Temperatures)
Charles Engelhard
Controllers (Electric)
General Electric Co.
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Goebel & Co., J.
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Chambers Brothers Co.
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Hardinge Co.
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Dryers (China Ware—Porcelain)
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Manufacturers Equipment Co.
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Philadelphia Drying Machinery Co.
Proctor and Schwartz, Inc.
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Wilson-Maeulen Co.
Electrical Porcelain Machinery
Crossley Machine Co.
Mueller Machine Co., Inc.
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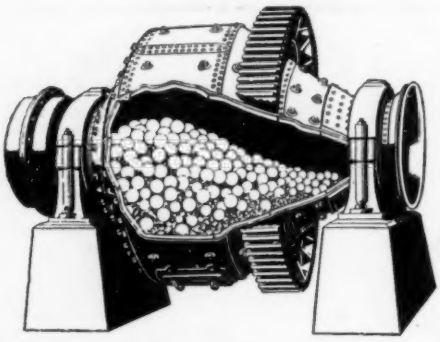
The Porcelain Enamel & Mfg. Co.
Enameling Furnaces
The Porcelain Enamel & Mfg. Co.
U. S. Smelting Furnace Co.
Enameling Muffles
Parker-Russell Mining & Mfg. Co.
Enameling, Practice Service
The Porcelain Enamel & Mfg. Co.
Enamels, Porcelain
The Porcelain Enamel & Mfg. Co.
Engineering Service
Abbé Engineering Co.
Crossley Machine Co.
Chambers Brothers Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.



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Extract of a letter from Daisy, Tenn.:

"We can but speak in the highest terms of the success this [Hardinge] mill is rendering in helping us manufacture the highest grade of floor tile."

It is the physical character of the product of the Hardinge Conical Mill that prompted this unsolicited endorsement.

This Company produces their product economically and without operating grief.

If you have a similar problem the information we have will interest you.

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Hardinge Conical Mills

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Proctor and Schwartz, Inc.
Russell Engineering Co.

Extruding Machines (Lab. Use)
Chambers Brothers Co.

Feldspar
Drakenfeld and Co., B. F.
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O'Brien and Fowler
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Crossley Machine Co.
Mueller Machine Co., Inc.

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The Surface Combustion Co.

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Roessler and Hasslacher Chemical Co.
Vitro Manufacturing Co.

Ilmenite
Buckman and Pritchard, Inc.

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Jar Mills
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Jiggers
Crossley Machine Co.
Hadfield-Penfield Steel Co.
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Harshaw, Fuller and Goodwin Co
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Kryolith
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Laboratory Mills
Abbé Engineering Co.
Crossley Machine Co.

Magnesia Refractories
General Ceramics Co.

Mills (*See under Ball Mills*)
(*See under Pebble Mills*)

Minerals
Drakenfeld and Co., B. F.
Harshaw, Fuller and Goodwin Co.
Roessler and Hasslacher Chemical Co

Mixing Machines
Chambers Brothers Co.

Muriatic Acid
Harshaw, Fuller and Goodwin Co.
Pennsylvania Salt Mfg. Co.
Roessler and Hasslacher Chemical Co.

Oxides
Drakenfeld and Co., B. F.
Harshaw, Fuller and Goodwin Co.
Paper Makers Chemical Co.
Pennsylvania Salt Mfg. Co.
Roessler and Hasslacher Chemical Co.

Pans (Wet and Dry)
Chambers Brothers Co.
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.

Pebble Mills
Abbé Engineering Co.
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Hardinge Co.
Mueller Machine Co., Inc.

Plate Feeders
Chambers Brothers Co.
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.

Porcelain Balls and Lining
Abbé Engineering Co.

Porcelain Enameling Plants and Equipment
The Porcelain Enamel & Mfg. Co.

Porcelain Enameling Service, Practical
The Porcelain Enamel & Mfg. Co.

Porcelain Enamels
The Porcelain Enamel & Mfg. Co.

Pottery Machinery
Abbé Engineering Co.
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.

Producer Gas Burning Systems
Manufacturers Equipment Co.

Pug Mills
Chambers Brothers Co.
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.

Pulverizing Machinery
Abbé Engineering Co.
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.

Pulverizing Mills
Abbe Engineering Co.
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Hardinge Co.
Mueller Machine Co., Inc.

Pumps
Abbé Engineering Co.
Mueller Machine Co., Inc.

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Wilson-Maeulen Co.

Pyrometers (Recording)
Charles Engelhard
Wilson-Maeulen Co.

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Montgomery Porcelain Products Co.

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General Ceramics Co.

Silex Lining
Abbé Engineering Co.

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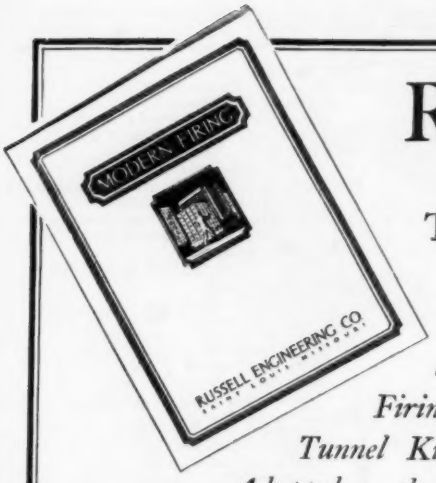
U. S. Smelting Furnace Co.
The Surface Combustion Co.

Sulphuric Acid
Drakenfeld and Co., B. F.
Harshaw, Fuller and Goodwin Co.
Pennsylvania Salt Mfg. Co.
Roessler and Hasslacher Chemical Co.



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This New Book is a Treatise on the Scientific and Modern System for Firing all Clay Wares in the Tunnel Kiln. The Russell Kiln is Adapted to the use of Producer Gas, Oil or Natural Gas as Fuel.

A Copy of "Modern Firing" Awaits Your Request

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RAILWAY EXCHANGE BUILDING *ST. LOUIS, MO.*
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for white and opalescent glass

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Tile Machinery (Floor and Wall)
Crossley Machine Co.
Mueller Machine Co., Inc.
Tubes (Insulating)
Montgomery Porcelain Products Co
Tubes (Pyrometer)
Charles Engelhard
Montgomery Porcelain Products Co.
Tube Mills
Abbé Engineering Co.
Tunnel Kilns
Russell Engineering Co.
Vacuum Pumps
Abbé Engineering Co.
Whiting
Drakenfeld and Co., B. F.
Harshaw, Fuller and Goodwin Co.
Roessler and Hasslacher Chemical Co
Zircon (Miners of)
Buckman and Pritchard, Inc.
Zirconium Silicate (Fire Cement)
Buckman and Pritchard, Inc.
Zirconium Silicate (Refined)
Buckman and Pritchard, Inc

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We build every machine and appliance required for making various Clay Products. Correspondence solicited. We also build Rotary Driers, Cement Mchy., Fuel Oil Engines (Diesel Type), Gasoline Locomotives, Ship Deck Equipment, etc.

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Producers of the famous Derry Spar

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12-21

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REALLY washed—Highest percentage clay substance

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4 ft. style "B" Dry Pan

We are engineers to the clay-worker

We have been in business since 1879.

You are invited to benefit by our extensive service. Our catalog will interest you. Write for it.

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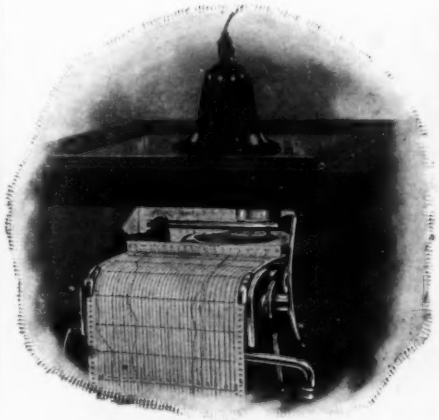
1-22



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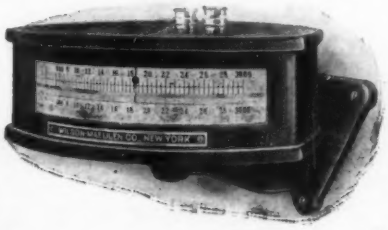

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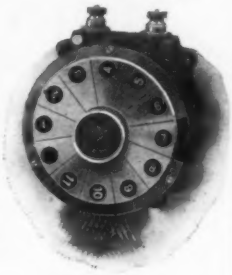

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5-22

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SMELTERS
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EQUIPPED FOR KEROSENE OIL,
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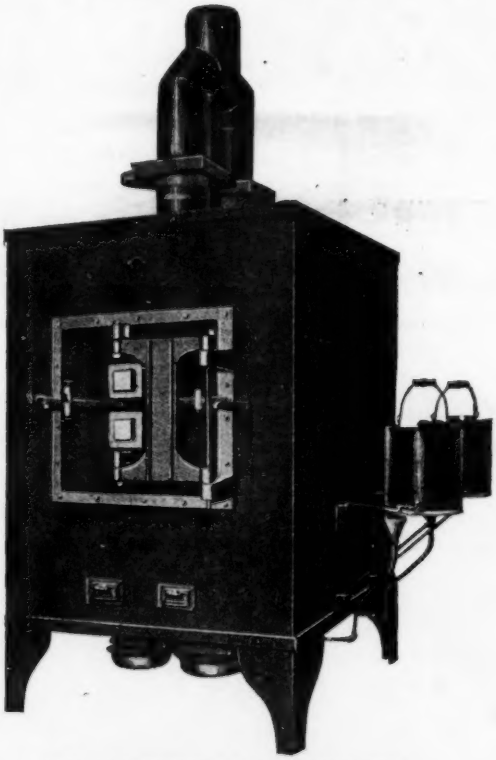

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Equipped With Kerosene Oil Burners

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Zircon is used to advantage in place of Sillimanite, Fused Silica, Alumina and Kaolin.

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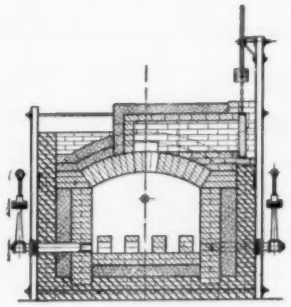

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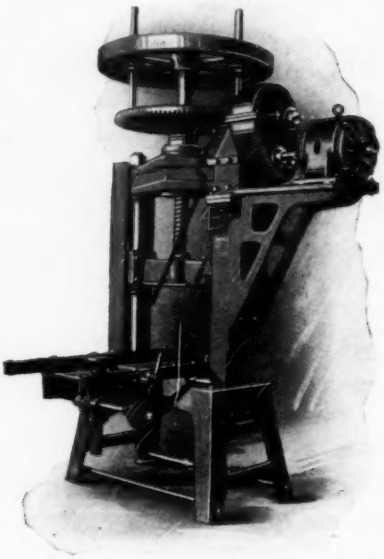

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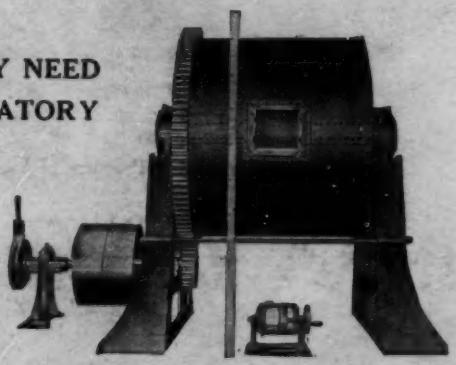

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